Vol. XXVIII, No. 9 Whole No. 245

DECEMBER, 1928

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

Remedial Arithmetic
Fundamentals of Science
Rotational Inertia Apparatus
Methodology in Biology
Nucleus of the Atom

Published by THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS
Publication Office: 404 N. WESLEY AVE., MOUNT MORRIS, ILLINOIS
Business Office: 1439 FOURTEENTH ST., MILWAUKEE, WISCONSIN
Editorial Office: 7633 CALUMET AVE., CHICAGO, ILLINOIS

Published monthly, October to June, Inclusive, at Mount Morris, Illinois *Price, $2.50 Per Year: 35 Cents Per Copy*
Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

"If we wish to erect new structures we must have definite knowledge of the old foundations."—*Calvin Coolidge.*

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School Science and Mathematics

A Journal for All Science and Mathematics Teachers

Published Monthly except July, August and September.

PRICE. The subscription price is Two Dollars and Fifty Cents a year; Canada $2.75; foreign countries $3.00; single copies 35 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add five cents for collection. Remit to **School Science and Mathematics, 1439 Fourteenth St. Milwaukee, Wis.**

CHANGE OF ADDRESS. Subscribers should send notice of any change of address before the 12th of each month; otherwise they are held responsible for magazine, sent to their former address, and no duplicate copies will be sent except on payment of 35 cents for each copy. Send notices to **School Science and Mathematics, 1439 Fourteenth St. Milwaukee, Wis.**

MISSING NUMBERS will be replaced *free* only when claim is made within thirty days after receipt of the number following.

REPRINTS, if desired, must be ordered in advance of publication. Reprints of leading articles will be printed as ordered, the actual cost (with cover, if desired) to be paid for by the author.

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXVIII No. 9 DECEMBER, 1928 WHOLE No. 245

SOLVING PROBLEMS IN ARITHMETIC.

BY FLETCHER DURELL,

Belleplain, N. J.

Rearranging and to some extent modifying the statement of G. W. Myers in a recent number of SCHOOL SCIENCE AND MATHEMATICS (March 1928, P. 281) we may separate the study of arithmetic into three parts as follows:

I. The acquisition of skill in purely numerical operations, as in adding, subtracting, and multiplying numbers, adding fractions, etc.

II. Problem solving, or the application of skill in numerical calculations to the solution of specific, concrete, number problems, such as may arise in business or everyday life.

III. The development in the pupil of a facile and comprehensive number sense to be used in giving perspective and system to life in general.

On the part of the teacher and the pedagogist, the first of the above three divisions includes the formation of lists of computation skills and the investigation of the best methods of acquiring them. Some of the details are the study of the relative frequency of addition and other number combinations, the collection and listing of common errors and pitfalls, and the analysis of their sources, the formation of diagnostic tests, the study of the best remedial methods, and so on. A somewhat thorough study of these and like topics has been made during the past few years by many investigators from different points of view, and the results obtained have been recognized as reasonably satisfactory and complete, and have been widely applied in practice both in text books and the class room.

The great importance of the third of the above three general objections or divisions of arithmetical study has just begun to be definitely recognized and special methods of treating the matter in the class room have as yet received almost no attention.

At present the efforts of arithmetical investigators seem to be converging upon the study of the second of the above parts of the subject, the solution of concrete problems, including a determination of both the extent to which this topic should be taught to various types of mind, and the best methods of giving such instruction. It is the aim of the present paper to try to make some contribution to this matter of problem solution.

It is evidently desirable at this outset, if possible, to form a short list of the most fundamental and essential types of problems. The plan would then be to discover or devise the best methods of mastering these pivotal primary types, leaving special cases to be treated in subordinate and auxiliary ways.

As an aid in making this list of fundamental types of arithmetical problems it is important to make a distinction between the number of different kinds of computation processes and the number of steps (or operations) required in solving a given problem. Thus if the numerical work involved in the solution of a problem consists only of additions and multiplications it is a two-process problem. But if this solution consists of two multiplications and one addition it is a three step (or three-operation) problem. The following is a problem of the kind just described.

Ex. A woman went to a store and bought 8 lb. of sugar at 6c a pound and 2 lb. of coffee at 35c. Find the total cost of her purchases.

As just said this is a two-process but a three-step problem.

Considered with respect to the processes involved in its solution a convenient symbolism for this kind of problem is $(+\times)$. Considered as a step problem, the corresponding symbolism would be $\begin{bmatrix} +\times \\ \times \end{bmatrix}$.

It is to be noted that in this notation, for reasons which will soon be evident, the sequence of operations to be performed is not followed, but the order in which the processes occur in the fundamental sequence $+,\ -,\ \times,\ \div$.

Taking the combinations of the four primary processes (addition, subtraction, multiplication, and division) one, two, three, and four at a time, we obtain, thus, the following fifteen fundamental types of problems expressed symbolically:

I. Four one-process types, viz: (+), (−), (×), (÷).

II. Six two-process types, viz: (+ −), (+ ×), (+ ÷), (− ×), (− ÷), (× ÷).

III. Four three-process types, viz: (+ − ×), (+ − ÷), (+ × ÷), (− × ÷).

IV. One four-process type, viz: (+ − × ÷).

The following 15 examples illustrate the above fundamental types in order.

Ex. 1. A boy paid 6 cents for a pencil and 8 cents for a pad. How many cents did he spend altogether? (+ type)

Ex. 2. A woman had 17 hens and sold 4 of them. How many did she have left? (− type)

Ex. 3. Find the cost of 8 lb. of sugar at 6 cents a pound. (× type)

Ex. 4. At 3 cents each how many apples can be bought for 15 cents? (÷)

Ex. 5. At one time there were 19 passengers on a trolley car. At the next stop 8 passengers got off and 5 got on. How many passengers were then on the car? (+ −)

Ex. 6. A girl sold a sweater for $6.50 and three hand bags for $2.00 each. How much did she receive for these altogether? (+ ×)

Ex. 7. One week Arthur recited four times in history and received the following grades: 6, 10, 7, and 9. Find his average mark for the week. (+ ÷)

Ex. 8. An automobile had a trip of 120 miles to make. After going three hours at 27 miles an hour, how many miles did it still have to go? (− ×)

Ex. 9. A boy wished to buy a radio set whose cost is $30. He has already saved $18. How much must he save on the average during each of the next three months in order to be able to buy the set for cash at the end of the three months? (− ÷)

Ex. 10. If 6 apple trees yield 18 bushels of apples, at the same rate how many bushels should be obtained from 29 trees? (× ÷)

Ex. 11. A woman bought a pound of coffee for 35c and 12 lb. of sugar at 5c a pound. How much change did she receive from a two-dollar bill? (+ − ×)

Ex. 12. In four successive hours a car travelled the following distances in miles: 27, 32, 36, and 35. By how much did its average speed exceed 30 miles per hour? (+ − ÷)

Ex. 13. A farmer sold three cows for $62 each and a fourth cow for $74. What was the average selling price of the cows? (+ × ÷)

Ex. 14. A man bought 5 tables at $12 each. He paid $20 down and the rest of the cost in 8 equal installments. How large was each of these 8 payments? (− × ÷)

Ex. 15. A man bought 6 tables at $7.50 each. Toward the total cost of these he has made two payments of $7 and $5 respectively. He wishes to pay the rest of the cost in four equal payments. How large must each of these payments be? (+ − × ÷)

In teaching the solution of problems in arithmetic, the first thing to do is to make sure that the pupil masters these elementary types (or such of them as are included in the work of any particular grade) as thoroughly as possible, though of course the pupil may be entirely unaware that this system of types is being used.

Such a mastery will not only be worth while for its own sake,

but by it the solution of more complicated cases where each computation process may occur twice or oftener will be made easier, and in teaching different pupils the degree of complication may be readily limited at any desired point. In proportion as this fundamental mastery is thorough many of the simpler of these special cases of complication will take care of themselves, at least with some slight informal help from the teacher. The still more complicated cases can be left as extra credit work for the brighter pupils.

Hence it is of the first importance to see that the fundamental types are thoroughly grasped and that the process of their mastery, if possible, shall be easy and natural and thoroughly enjoyed by the pupil. We shall therefore consider next some of the special methods for obtaining this desired mastery of the 15 primary types. The description of these methods will be made as detailed and elementary as the space at our disposal will permit, the object being to present them in a form adapted primarily to the instruction of the lowest level of arithmetical ability found in the ordinary class, and yet in a form adapted to syncopation and acceleration for brighter pupils.

Let us suppose that we are giving instruction in the (+ −) type of problem (see Ex. 5 above). We might begin with a group of problems like the following:

Ex. 1. A boy bought an orange for 5 cents and an apple for 2 cents. He handed the clerk a dime. How much change did he receive?

Ex. 2. A pupil bought a pad for 8 cents and a pencil for 6 cents. He gave the store keeper 25 cents. How much change did he receive?

Ex. 3. A girl bought a glass of milk for 5 cents and a sandwich for 10 cents. How much change should she receive from a half dollar?

Not only are all of these problems of the same type, viz: the (+ −) form, but in all of them the language form is the same essentially, and is the simplest possible. Only short direct sentences are used. The narrative or story form is used. What is given is stated first and afterward what it is required to find. In all these problems the actor is the pupil or child. All of the numbers used are small integers, and are the same kind of concrete number, i. e. cents. The scene in which all of the problems is laid is the same, i. e. the store.

The only essential element of difference is in the size of the numbers.

If desired the problems can be made even more uniform by making the articles purchased the same in every problem, as for instance a pencil and a pad.

If it be objected that the uniformity among the given problems is too great, one reply is that there is an even greater uniformity in the examples given in an elementary drill in processes with pure numbers.

The idea underlying the above first drill in the $(+-)$ type of problems is that the type of problem considered shall be repeated till the pupil has mastered it in this limited form and shall not hesitate to write the symbolism $(+-)$ as descriptive of it, and to use any simple formalism in connection with it, that may be desired by the teacher, such as outlining the work for Ex. 1 in the following partially verbal way: change $=10-(5+2)$. It should be stated however, that it is an entirely secondary matter whether our symbolism or any special form of arranging the steps of a solution be used in connection with the plan of studying word problems here outlined; this matter will be treated more fully later.

Such exercises or drills in solving problems as we have just described can gradually be made more difficult by varying anyone of the elements of uniformity specified above, as language, scene, actor, etc.; or any combination of these features. Thus could be obtained a succession of exercises of gradually increasing difficulty, all bearing on the mastery of one fundamental type of problem.

The following are specimens of such variant forms of the type of problem under consideration:

Ex. 1. If Mary bought a pencil for 5 cents and a pad for 12 cents, how much change did she receive from a quarter?

Ex. 2. A man in an automobile had a trip of 212 miles to make. One day he made 87 miles and the next day 65 miles. How many miles did he still have to go?

Ex. 3. How much money did a boy have left, if he had \$42.50 to start with and spent \$8.50 of it for a sweater, and \$6.15 for a tennis racket?

After one of the fundamental fifteen types has been mastered, a second of these types can be studied in like manner, then practice will be given in which problems of the two types are mixed together and the pupil is taught to discriminate between them, and so on till all the types for any given grade have been covered.

As has already been suggested, it may seem to some that a drill in problems so much alike as the first set of three problems given above, and such minute gradations in difficulty in the succeeding exercises is puerile and will make progress unnecessarily slow. But the more investigators look into the matter the more evident it becomes that in much of the past instruction in problem solving we have been shooting over the heads of pupils.

One of the principal ways in which we have done this, is in not realizing how slight a change needs to be in a problem to make it an entirely new problem to some pupils. To take an illustration from another field, the writer in teaching geometry once assigned this original: "prove the diagonals of a rectangle equal." Shortly afterward he gave the same class this original: "prove the diagonals of a square equal." To most of the class the latter seemed an entirely new exercise. Not one pupil in five realized that the two exercises were essentially the same.

Thus far in the discussion we have supposed that the only kind of numbers used in problems were integers or United States money. Further and higher stages of the mastery of problem solving will be attained by the study of problems containing other kinds of numbers as fractions, decimals, and measures, and requiring the use of the computation technics connected with them.

For instance a pupil may be able to analyze and solve a problem of a given type containing only small whole numbers, and yet be confused and helpless when asked to perform what is essentially the same reasoning process in connection with fractions.

Ex. A man at his death left ¼ of his property to his only daughter and the rest to be divided equally among his five sons. What fractional part of his property did each son receive?

This is a type 9 or $(- \div)$ problem. Yet a pupil might very well be able to solve Ex. 9 in the list of fifteen examples given on page 927, where only simple integers occur, and not be able to solve the problem just given because of lack of mastery of certain technical processes peculiar to fractions. Thus in solving the problem just stated, he must be able to express the man's entire property by 1, to subtract ¼ from 1, and to divide the result by 5. If the teacher finds that the pupil can solve Ex. 9 in the list of fifteen examples, but cannot solve the fractional problem just given, the teacher will know that the pupil can do the reasoning involved, but has difficulties owing to a lack of facility in handling fractions and the teacher can apply remedial measures accordingly.

Hence further stages of mastery will be the study of the 15 types of problems under consideration, in connection with each of the other leading topics in arithmetic, as fractions, decimals, measures, percentage, interest, and mensuration.

It may be useful to observe that our symbolism for indicating

the process nature of a given problem may be extended to cover these further stages. Thus if "fractions" be denoted by fr., "decimals" by dec., "percentage" by %, the symbolism $\left[+\times\substack{\div\\ \div}\ \text{fr.}\ \%\right]$ will stand for a problem whose solution involved one addition, one multiplication, two divisions and the technic of fractions and percentage.

Valuable auxiliary drills contributing to a thorough mastery of the fundamental types of problems will be found in practice in inventing or making up problems of a given type; or in completing a partially given problem; in selecting from a page of mixed examples those which are of a given type; in solving problems which contain extra numbers; and so on. The details of such auxiliary drills must be left for consideration in another connection.

We have already, at certain places, touched upon those variations of the fundamental types of problems where a given process (as addition, etc.) is duplicated; that is, occurs more than once in a given example. We shall next consider these cases in more detail. The simplest instance is, of course, that where one, and only one, process occurs twice in the solution of a given problem.

Thus the balancing of an account involves two additions and a subtraction and is a variation of the fifth fundamental type of problem. Hence it is represented by the following process symbolism $\begin{bmatrix} + & - \\ + & \end{bmatrix}$

So for the following problem:

Ex. A woman bought 8 lb. of sugar at 6 cents a pound and 2 lb. of coffee at 34 cents. How much change did she receive from a five-dollar bill?

the type would be number 11 and the symbolism $\begin{bmatrix} + & - & \times \\ & & \times \end{bmatrix}$

It will be found that if the 15 primary types have been thoroughly mastered the slight variations of these types which have just been described will largely take care of themselves. In proportion as the study and mastery of the primary cases has been thorough and pupils have enjoyed this study and thus built up a sense of confidence, realized the joy of achievement, and acquired a kind of swing and momentum, will the attack and assimilation of slightly variant cases follow naturally and often with little or no special effort. The battle has been won when pupils begin to say to each other that problem solving is a

"cinch," and when, as sometimes happens, they ask for harder problems that they may experience a greater joy of achievement.

We have discussed thus far the study of the 15 elementary types of problems and of certain slight variations and complications of them. It will be found that this range of problems covers at least 90 per cent of all the problems that the average pupil will ever be called upon to solve in practical life, and also the mastery of all of the principal fundamental kinds of reasoning used in the everyday thought of the world.

It remains to discuss the still more complicated forms of problems than those already mentioned. As an illustration of the more complicated types let us take the following example:

Ex. A grocer bought 50 dozen eggs at 38c a dozen. Of these he sold 22 dozen at 48c and the rest at 45c. He estimated his expense in handling all the eggs at 75c. Find his profit per dozen eggs.

The outline of the numerical work in solving this problem is as follows:

$$\text{Profit per dozen eggs} = \frac{22 \times .45 + (50-22).48 - (50 \times .38 + .75)}{50}$$

$$\text{Using our process symbolism we get} \begin{bmatrix} + - \times \div \\ + - \times \\ \times \end{bmatrix}$$

As compared with many problems in our current texts this problem is not unreasonably difficult and is fairly "real." However, in the writer's opinion, such problems should not be assigned to mixed classes as a whole, but should be given to brighter pupils as extra credit work.

In the third year book of the National Council of Teachers of Mathematics (p. 248) it is stated that "we constantly overestimate the child's ability to reason. Most problems given to pupils are too difficult for them." So Myers says (SCHOOL SCIENCE AND MATHEMATICS, March 1928, p. 281): "Most of the literature for teacher-training and guidance in journals as well as in the texts, overstresses the importance of problem-solving ability as the one criterion of the mastery of arithmetic"; and again "the social demand for arithmetic never for any but skilled professionals rises to the complexity of skill with such word problems as are in most of the school arithmetics."

By attempting in the past to teach all pupils alike, problems more complicated and difficult than will ever arise for most of them in actual life, and that without a properly graded approach, we have too often made the topic a bugbear and too often cre-

ated a sense of helplessness and dread and in some cases a consequent dislike for the study not only of arithmetic but of mathematics as a whole.

One of the most important outcomes of the recent wide use of intelligence tests has been the movement toward the so-called ability grouping of pupils; that is, so organizing the work that instruction shall be adapted to the special grade of ability, if not of each pupil, at least to certain special levels of ability among them, as to sections of pupils below-average, average and above-average.

Of all the topics to be studied and skills to be acquired in arithmetic, problem solving probably shows the widest divergence or range of ability among pupils. Hence in this subject there is the greatest call for the organization of the matter with reference to different levels of ability and different capacities of individual pupils.

In order to apply the method of ability grouping there is need (1) of satisfactory methods of classifying pupils into sections according to ability levels; (2) and of a proper technic of administration and instruction of each section. In both of these processes as applied to problem solving, the use of the few fundamental types, and the use of the minutely subdivided scale of difficulty applied to each as suggested in this paper will be helpful. Also by limiting the work on word problems given to sub-average and average pupils to the more elementary types and cases, the problems used may be made more real and natural, the more unusual, complex, and artificial ones being assigned only to the more gifted pupils and sections.

At this point some statement should be made concerning certain formal methods often advocated as an aid in problem solving. One of the most common of these is the so-called six-step (sometimes five-step) method. The proposed six steps to be used in solving each problem are as follows:

1. Statement of what is given.
2. Statement of what it is required to find.
3. Writing of list of operations to be performed.
4. Making an estimate of the answer.
5. Computation.
6. Checking of results obtained.

Some of those who have experimented with this method claim that it has given valuable results. Others assert that it does not pay for the great amount of extra labor which it entails; and

that for a teacher who has a large class the labor involved in inspecting each of the six steps in the solution of every problem worked by pupils and seeing that each step is not only correct but in good form, is prohibitive. In other words the method is declared to be a "teacher-killer." When the examples are relatively simple the pupil also objects to doing so much work that seems to him needless, and it exhausts the nervous force of the teacher to compel pupils to do this apparently needless work.

Again this six-step method is utterly impractical in the actual business world as in grocery or dry goods stores. Clerks there must calculate in more expeditious ways.

However, after some experimentation, the writer is of the opinion that a certain limited amount of drill in this six-step method is beneficial for pupils and is within the bounds of feasibility for most teachers; but that after learning to solve a problem in this full formal way, the pupil should learn to telescope the process by doing part of it mentally. Also when bright pupils are trying to solve an especially difficult or complex problem, this method may sometimes be a helpful resource.

If this formal method is used either in this limited way or regularly in its complete form, its application will be greatly aided by using it in connection with the fifteen fundamental types and other cases advocated in this paper. Thus, if applied to anyone of these types over and over till that is mastered, the process of the formal use of the six steps will soon become automatic and will readily be telescoped in the pupil's mind into a briefer and more practical form without losing any of its essential values.

The methods of treating word problems in arithmetic that have been presented and advocated in this paper have important relations with the principles of co-operative mathematics which have been discussed by the writer in preceding articles in this magazine (see December, 1927 and January, 1928). Thus, if the degree of system and order in the succession of topics (as integers, fractions, decimals, etc.) therein advocated be preserved, the corresponding evolution of a thorough grasp of the technic of solving problems is greatly facilitated. Reciprocally, this study of problems in progressive stages puts life and interest into the successive formal drills. Or, to put the matter in a more general way, intimate co-operation between the formal abstract process of arithmetic and the concrete uses of the same is organized and developed. This may be termed internal co-operative mathe-

matics, that is, co-operation between the constituent topics of a special branch of study.

The method also has external co-operative relations with other branches of mathematics and other studies in general. As a means to the efficient and thorough mastery of any subject, too great a stress cannot be laid upon the importance of determining the few fundamental concepts and processes in that department of knowledge and the early thorough mastery of these from every possible point of view. If these few primary essentials are properly grasped, the process of assimilating the rest of the subject should be largely of a spontaneous and self-developing nature. If this method is followed in the study of arithmetical problems and the understanding of them becomes a kind of instinct, the habit thus formed will aid in the mastery of algebra, geometry, and other branches of study in the same way.

MAY CHECK MONOXIDE POISONING.

Carbon monoxide victims in closed garages and suicides by the gas route will in future become less numerous if the resuscitation method now being tried out by Dr. Ludwig Schmidt-Kehl of the University of Würtzburg works as well on human beings as it has on cats in the laboratory. Cats so far gone with carbon monoxide asphyxiation that they would surely have died have been "brought to" by placing them in a closed chamber of pure oxygen under pressure which was alternately decreased and increased in time with their own natural breathing rate.

Carbon monoxide poisoning, Dr. Schmidt-Kehl explains, is due to the abnormal appetite of the red blood corpuscles for the unwholesome gas. They take it up 250 times as readily as they do oxygen, which is the burden they normally carry to the body cells. The latter, deprived of their ration of oxygen, die of internal suffocation.

With the red corpuscles out of commission, the situation might seem to be hopeless. But the German physiologist points out that the blood fluid itself, which ordinarily carries so little oxygen that it cuts no practical figure at all in respiration, may be induced to load up with an emergency ration by placing the asphyxiated animal or person in a closed chamber of oxygen under pressure.

If the pressure is kept at a uniform level it must be relatively high; but Dr. Schmidt-Kehl has found that much lower pressures can be used if these are alternately increased and lowered, in time with the breathing rate of the victim. This simulated breathing in a closed chamber, he has found, is much more likely to revive semi-asphyxiated animals than a uniform high pressure.

Thus far the work has been done only with a small experimental apparatus, with a chamber only large enough to contain a cat. Considerable difficulties have still to be overcome before the method can be adapted to clinical use for saving asphyxiated human beings.—*Science News-Letter*.

THE STRUCTURE OF THE NUCLEUS OF THE ATOM.

By Walter O. Walker,
William Jewell College, Liberty, Mo.

The first attempt to show any systematic relation between the elements was made by Prout. His hypothesis stated that all of the atoms were made up of multiples of hydrogen, and that all atomic weights were whole numbers, when based on the ratios considering hydrogen as one. Due to the fact that later atomic weight determinations proved that this relation did not exist, the hypothesis soon was discarded. The idea was basically sound but was founded on incorrect data.

In 1915, Harkins and Wilson published the Whole Number Rule, which reiterated Prout's Hypothesis, to the extent of stating that hydrogen was the only true primal element. They stated:

(1) That the atomic weights of the atomic species are close to whole numbers on the basis of oxygen as sixteen.

(2) The atomic weights may be expected to be closer to whole numbers when they are divisible by four than when they are not.

From this, it follows that all atoms are simply intra-atomic compounds of hydrogen, and that all atoms whose atomic weights are divisible by four may be composed either of positively charged hydrogen atoms (positive charges, usually termed protons) or of a combination of protons and electrons to form the equivalent of the alpha particle. The atomic numbers are too close to whole numbers to be accounted for by chance.

Experimental work indicates that atoms are made up of protons and electrons. In order to maintain electrical neutrality, the number of protons in the atom must be equal to the number of electrons. On this basis the formula for calcium, atomic weight, 40, is $P_{40}e_{40}$. This takes in the entire structure of the atom and not simply the nucleus. The structure of the outer portion of the atom will be considered in a later paper. This paper deals with the structure of the nucleus.

Harkins assumes that four atoms of hydrogen less two of the accompanying electrons combine to form the helium nucleus or alpha particle. Hydrogen has an atomic weight of 1.0078. When four hydrogen atoms combine to form one helium atom, the atomic weight resulting should be four times that of hydrogen. That however is not the case, the atomic weight of helium being less than the value necessary for the assumption of the condensa-

tion of hydrogen to form helium. The difference in the theoretical weight and the atomic weight of helium, apparently has been lost in the process of condensation, being radiated as energy. Millikan's work on the Cosmic Rays seems to indicate that the difference in weight is radiated as Cosmic Rays. Harkins termed this phenomena the "packing effect." It is assumed that the protons and electrons are brought close together, with the electrons much closer than the protons. The amount of energy required to bring the electrons close together is very slight, while that for the protons is much greater. Hence it is assumed that the protons are held rather farther apart than are the electrons. Mathematically the packing effect seems to be a fairly reasonable phenomena.

The work of Moseley established the fact that the nucleus of the atom has a positive charge which is numerically equal to the position of the atom in the periodic table. (There are a few exceptions to this general rule.) This number of positive charges has been termed the atomic number, and at the present time, gives us considerably more insight into the structure and characteristics of the atoms than does a study of the atomic weights.

Harkins has stated that the nuclei of the atoms are made up of alpha particles and protons and electrons. For the first twenty-six elements the structure of the nuclei is comparatively simple, being made up, for the most part, of alpha particles, for elements having even atomic numbers, and alpha particles and protons and electrons, for elements having odd atomic numbers. Above element twenty-six the structural relations become more complex, but are simplified somewhat on passing element eighty.

It is proposed to classify the elements into those having even atomic numbers and those having odd atomic numbers. By far the more abundant elements have even atomic numbers. Since, we assume, an even atomic numbered element nucleus is made up of alpha particles and the odd of alpha particles and protons and electrons, it is obvious that the former will be more stable than the latter, due to its simplicity of construction. If the atomic nucleus is more stable then the element whose nucleus is more stable should be the more abundant in the universe. In stone meteorites, 97.59% of the elements are even atomic numbered. In the iron meteorites 99.22% are even atomic numbered. In the earth's crust, which is not a uniform sample of the earth, 85.74% of the elements are even atomic numbered. Among the rare earths, the most abundant elements are even

atomic numbered. Of the undiscovered elements for which there are places in the periodic table, not one has an even atomic number.

It seems plausible, in view of the above facts, to assume that the more stable nuclei are those made entirely of alpha particles. From one to twenty-seven the atoms of even atomic numbers are very stable as shown by their abundance in the universe. From twenty-seven to eighty, the elements are not abundant. From eighty to ninety-two, there is a slight increase in the abundance of the elements.

If we divide the number of electrons in the nucleus by the number of protons, we get a value in the case of the first twenty-six elements, which is 0.5. Whenever this value becomes larger than 0.5 electrons and protons must be added in such a fashion as to keep the ratio constant; i.e. two protons to one electron. The electrons which are added in this case are termed cementing electrons. During radioactive changes these cementing electrons are the ones which are shot out of the nucleus. The electrons which are incorporated in the alpha particles are called binding electrons. They apparently are not shot off during radioactive changes.

Following is a summary of some of the important facts regarding elements which have nuclei made up of alpha particles and of protons and electrons.

(1) Almost all nuclei contain an even number of electrons.

(2) Most nuclei contain an even number of protons.

(3) When the number of protons is odd, the number of electrons is odd.

(4) All of the electrons in the nucleus serve either as binding or cementing electrons.

(5) It is supposed that the extra protons in the nucleus form a ring about the alpha particle portion while the extra electrons attach themselves directly to the stable portion of the nucleus.

The periodic system or table is founded on the chemical characteristics of the atom, which in turn is dependent on the atomic number of the element as well as the arrangement of the electrons in the outer portion of the atom.

In conclusion, it is quite evident that we know very little about the structure of the atomic nucleus. The aim of the writer has been to point out in a sketchy fashion a possible structure for the nuclei. For those who desire further material on this subject it would be best to consult the following articles,

all of which are by Harkins and all in the Journal of the Franklin Institute.

Vol. 194—No. 2, 3, 4, 5, 6.
Vol. 195—No. 1, 4.

The writer claims no originality for the material presented. It has been in use for some years in connection with a course presented by the writer on atomic structure.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
University of Oklahoma, Norman, Okla.

Many a man fails to become a thinker for the sole reason that his memory is too good.—*Nietzche, "Maxims."*

A teacher of Physics might well begin his instruction with the words of Demosthenes, "In the name of the gods I beg you to think." *A. Wilmer Duff in "Physics for Students of Science and Engineering."*

Learning, undigested by thought, is labor lost; thought, unassisted by learning, is perilous.—*Confucius.*

The road to true philosophy is precisely the same as that which leads to true religion; and from both the one and the other, unless we would enter in as little children, we must expect to be excluded totally.—*Francis Bacon.*

The great end of life is not knowledge but action.—*Thomas Henry Huxley in "Technical Education."*

It is now quite possible, in fact it probably has been done, for a boy to go straight through from his letter blocks to his Ph. D. with precisely the same kind of cooperation in the enterprise on his part that a sardine furnishes to the business of his translation from the state of innocence and freedom of his birthplace to the diploma-bearing tin on the grocer's shelf. All that is requisite is a certain self-effacing conformity to a series of propulsive mechanisms.—*Raymond Pearl, biologist, in "The Reading of Graduate Students," Scientific Monthly, Vol. 21. This paper can be read with much profit by students who contemplate entering graduate work in any of the natural sciences; as for those who are responsible for the training of such students, they too may receive some enlightment in its perusal.*

Nothing is secret that shall not be made manifest.—*Luke VIII, 17.*

The light in the world comes principally from two sources,—the sun, and the student's lamp.—*Bovee.*

A ROTATIONAL INERTIA APPARATUS OF NEW DESIGN.

BY W. L. KENNON,

University of Mississippi, University, Miss.

The value of an exact experiment in the mechanics of rotation adapted to the first course in laboratory physics led the writer some years ago to experiment with various devices in the attempt to develop an inexpensive type of apparatus free from complicated adjustments and accessory attachments, and which might be capable of yielding exact data which would illustrate in a simple and direct way the more important quantities involved and their relationships.

The design adopted has been in use over a period of five years and has proven so satisfactory that it has been made generally available in the form illustrated. It consists essentially of a brass disc about 25 cms. in diameter, 1 cm. thick, having a mass of about 4.2 kilograms. The disc is mounted with high grade ball bearings and is provided with a suitable wall bracket. A fibre disc 8 cms. in diameter and 1 cm. thick is fastened concentrically to the brass disc. The disc is set in rotation by a bob or weight of 100 to 150 gms. mass attached to a fine silk braided fishline which is wound over the fibre disc and attached to it by a loop which passes over a small peg set in the rim of the disc. A small platform provided with a specially designed spring-catch release operated by a pull cord serves to release the bob at the proper moment. The entire outfit is very positive and "true" in its action; and data from which the moment of inertia of the brass disc may be found within an error of one percent may be secured within ten to fifteen minutes.

More important even than the direct and expeditious way in which the apparatus lends itself to accurate manipulation is the "theory" or discussion to which it gives rise. As will be shown presently, this discussion not only involves but logically presents many important quantities and relationships concerning which the beginner's mind is often vague or confused. In order to present this point of view, as well as to show what may be expected of the apparatus, the results of several typical experiments are given together with a brief description of the manner in which the apparatus is used.

To carry out an experiment for the moment of inertia of the disc the following preliminary data is carefully determined; the radius (r) of the fibre disc (average of values taken before and

after the fishline has been wound on), mass (m) of the bob, distance (h) from platform to floor. In order to check the experimental value against that computed from the dimensions of the disc (using $I = MR^2/2$), the radius (R) of the brass disc and its mass (M) are obtained. For convenience the latter is stamped on the disc. Good results are obtained with the apparatus when it is mounted about two meters above the floor, which brings it within easy working reach. However, there is very little objection to mounting it at a higher level, if preferred; since the only

THE KENNON ROTATIONAL INERTIA APPARATUS

occasion to reach the disc is to rewind the fishline, for which purpose a little knob is attached to the fibre disc.

Having secured the preliminary data, which may be determined once for all if desired, it is merely necessary to release the bob (which we are assuming has been wound up and placed in position on the platform) and time its descent to the floor with a good stop watch. In order to secure data for the application of a correction for friction the time required for the disc to come to rest after the bob strikes is also determined. If available another watch is used for this purpose and is started just as the bob strikes the floor. If a second watch is not available the constancy of the friction in successive trials is such that a second trial may be used to secure this interval.

The following elementary analysis is given to illustrate the numerous "teaching opportunities" offered. The moment of inertia of the disc may be derived directly from the defining equation $I = T/\alpha$, ...(1)
where (T) is the torque effective in producing the angular acceleration. This effective torque is due to the force action of the descending bob minus the torque (T′) due to friction. Since the descending mass has in general a linear acceleration (a), the torque effect which it produces at the radius (r) is given by the expression $mr(g-a)$; and also since the friction torque destroys in t′ seconds the angular velocity set up in the disc in t seconds by the working torque (T), it must have a numerical value in inverse ratio to that of the working torque, that is, equal to $(t/t')mr(g-a)$. The torque effective in producing angular acceleration, therefore, becomes: $T = mr(g-a) - t/t' [mr(g-a)]$. Factoring and writing $a = 2h/t^2$, where h = distance traversed by descending bob, we have

$T = mr(g - 2h/t^2)\ (1 - t/t')$ ....(2)

The angular acceleration of the disc may be found as follows: Given the height (h) and the time of fall (t) of the bob, the velocity of the bob as it strikes the floor equals 2h/t. This may be taken also as the linear velocity of a point on the periphery of the fibre disc of radius (r). The angular velocity of the disc is then given by 2h/rt, and the angular acceleration by the equation:

$\alpha = 2h/rt^2$ ....(3)

Another approach to the same formula may be had from the consideration that the angle θ turned through by the disc in the time t is given (in radians) by the ratio h/r and hence the aver-

age angular velocity becomes h/rt, the final angular velocity 2h/rt, and the angular acceleration $=2h/rt^2$ as before.

Substituting the values of T and α from (2) and (3) into (1) we have finally for the moment of inertia of the disc in terms of the observed data:

$$I = T/\alpha = \frac{mr(g-2h/t^2)\,(1-t/t')}{2h/rt^2} = \frac{mr^2t^2(g-2h/t^2)\,(1-t/t')}{2h} \quad (4)$$

In this form the equation lends itself very readily to logarithmic calculation.

The experimental value thus obtained may then be compared with the value of I computed from the mass (M) and radius (R) of the brass disc using the formula $I = MR^2/2$.

The following typical experiments will serve to illustrate the application of the above formulae, and to show what may be expected of the apparatus.

EXPERIMENT 1.

Preliminary data: Mass (M) of brass disc $=4269$ gms.; radius (R) of brass disc $=12.73$ cms.; radius (r) of fibre disc $=4.06$ cms.; mass (m) of bob $=100.4$ gms.; height (h) of platform from floor $=206.9$ cms.

Trials	1	2	3	4	Average
Time of fall of bob in secs.	9.92	9.95	9.93	9.92	9.93
Time required for disc to come to rest in secs.	97.6	98.8	108.0	103.4	102.4

Substituting in (4)	Log.
$m = 100.4$	2.00173
$r = 4.06$; $r^2 = 16.48$	1.21696
$t = 9.93$; $t^2 = 98.60$	1.99388
$(g-2h/t^2) = (980-2\times206.9/98.60) = 975.8$	2.98936
$(1-t/t') = (1-9.93/102.4) = .903$	-1.95569
	8.15762
$2h = 2\times206.9 = 413.8$	-2.61679
	Log. $I = 5.54083$
	$I = 347.4\times10^3$gm-cm^2

Check; $I = MR^2/2 = 4269\times12.73^2/2 = 345.9\times10^3$gm-cm^2
I (for fibre disc) $=$ $.4\times10^3$gm-cm^2

I (for rotating system) $=$ 346.3×10^3gm-cm^2

Error $= +1.1\times10^3$gm-cm^2
Percent error $=0.32\%$

EXPERIMENT 2.

Preliminary data as in Exp. 1, except that $m = 120.4$ gms.

Trials	1	2	3	4	5	Average
Time of fall of bob in secs.	9.05	8.94	9.02	8.92	8.86	8.96
Time to come to rest in secs.	108.8	111.8	114.0	106.8	117.6	112.0

Substituting in (4)	Log.
$m = 120.4$ gms.	2.08063
$r = 4.06$; $r^2 = 16.48$	1.21696
$t = 8.96$; $t^2 = 80.26$	1.90461

$(g-2h/t^2) = (980-2\times 206.9/80.28) = 974.8$ 2.98892
$(1-t/t^1) = (1-8.96/112) = 0.92$ .... -1.96379

8.15491
$2h = 413.8$ .... -2.61679

Log. $I = 5.53812$
$I = 345.24\times 10^3$gm-cm^2
Check $I = 346.30\times 10^3$gm-cm^2

Error $= -1.06$
Percent Error $= 0.31\%$

Note of explanation: For ordinary use several of the refinements introduced in the above experiments may be omitted and hold within the 1% limit of experimental error. For example, a three-second watch reading to one-hundredth second was used in timing the bob. When timed with the usual tenth-second watch the time in the first experiment came out repeatedly 10 secs. instead of 9.93, and in the second experiment 9 secs. instead of 8.96. Evidently little if anything was gained by the use of the more sensitive watch. It is also evident that the moment of inertia of the fibre disc might be ignored if desired. Especially is this true since several of these quantities are compensating, as for example the mass of the fishline (one-half of which was added to the mass of the bob in the above) and the inertia of the fibre disc. If it is desired to simplify the experiment still further the acceleration of the bob may be ignored when its mass is not in excess of 100 gms. since its value is then only about 0.4% of that of gravity. However, the writer prefers to use masses of various magnitudes on the bob and make the acceleration a feature of the experiment. Ignoring the corrections mentioned and determining the friction directly by applying a suitable mass to a scale pan attached to the rim of the fibre disc the experiment can be simplified within reach of the most elementary student of physics and still be made to yield results of very respectable accuracy.

Another point of view may be introduced by checking the experiment with the energy equation, where the potential energy (mgh) of the bob with respect to the floor is placed equal to the sum of the kinetic energy ($mv^2/2$) of the bob as it strikes, plus the rotational energy ($I\omega^2/2$) stored in the disc, plus the work done against friction ($T^1\theta_{..}$) in the time of fall. The three terms on the right hand side of this equation are given respectively in terms of the observational data by ($2mh^2/t^2$); ($2h^2I/r^2t^2$); and (t/t^1) [$mr(g-2h/t^2)$] (h/r). (It is a good exercise for the student to show how these equivalent terms are obtained).

Using the equation just given either the moment of inertia may be computed and compared with the check value, or the check value of I may be introduced into the equation and the energy balance tested. Another exercise is provided by computing the efficiency of the wheel using the difference between the initial potential energy and final kinetic energy of the bob as the input and the rotational energy as the output.

Still another useful exercise and check is provided by comparing the force applied at the radius of the fibre disc that will just maintain uniform rotation once the disc is started, with

the "force of friction" computed from the friction torque (T') at the radius (r). This gives, of course, a direct experimental check on the friction torque as derived from the "stopping time." These values corresponding to the above experiments are as follows: Weight applied to rim of fibre disc to maintain uniform rotation = 9.76 gms. Grams of force (friction) computed from stopping time Exp. 1 = 9.89 gms., Exp. 2 = 9.58 gms.

It might be mentioned here that the value of the friction torque may be determined in the manner just indicated, if preferred, thus simplifying the calculations somewhat. The stopping time, however, would appear to give a better average value, though the results given above seem to indicate the contrary. In practice the two values are in general so nearly equal that the writer prefers to use this agreement as the basis for an exercise in the study of friction.

Entirely aside from the many quantitative relationships which the use of the apparatus illustrates, the student's attention is always arrested by the fact of the greatly reduced acceleration of the descending bob. This observation immediately takes on new importance when he realizes, as he soon must from the study of the friction involved, that friction alone cannot suffice to explain the small acceleration of the bob as compared with that of a freely falling body. The applications mentioned are but a partial list of the possibilities. The apparatus is especially useful in connection with lecture explanations and demonstrations in elementary mechanics.

As used in the laboratory, while the student must use care in securing his observations no experienced and exacting technique is required to get results of a high order of accuracy; as compared, of course, with the usual laboratory standards. In the reduction of the observations the student is required to think clearly and to handle the calculations accurately to avoid numerical errors, and here too the work is of a grade suitable to his degree of preparation. No accessory apparatus is required beyond a good stop watch and a meter rod which are part of every physics laboratory equipment.

BIRTHDAY ANNIVERSARIES.

Alexander Agassiz, Dec. 17, 1835.
Sir Humphrey Davy, Dec. 17, 1778.
Louis Pasteur, Dec. 27, 1822.

DO ALGEBRA STUDENTS NEED REMEDIAL ARITHMETIC?

By George A. Boyce,
Instructor in Elementary Mathematics, Western Reserve Academy, Hudson, Ohio.

Many teachers and parents have felt that success in Algebra is closely related to a youngster's success in Arithmetic. Very often the procedure for a beginning class in Algebra has been to spend the opening weeks of school teaching Arithmetic to students who appeared in need of work of this sort. The assumption has been that this would bring better results in the Algebra work to follow.

Is this assumption true? Is it necessary to remedy the Arithmetic deficiencies in order to insure success in Algebra? When should the remedial Arithmetic be introduced, if at all, in the Algebra class?

Let us consider first whether it is necessary to remedy the Arithmetic deficiencies in order to insure success in beginning Algebra.

E. W. Schreiber (Schreiber, E. W., "A Study of the Factors of Success in First Year Algebra," The Mathematics Teacher, vol. XVIII, No. 2, February, 1925, p. 65-78, and vol. XVIII, No. 3, March, 1925, p. 141-163. Also summarized in Department of Superintendence Sixth Yearbook, p. 338, February, 1928) found that partial correlations between Arithmetic and Algebra ranged from .13 to .30. His data was based upon the following tests in Arithmetic and Algebra given at the end of the school year.

Courtis Research Test—Addition.
Courtis Research Test—Multiplication.
Hotz Algebra Test—Equation and Formula—Series B.
Hotz Algebra Test—Problems—Series B.

The conclusion was that when students of equal mental ability are selected, addition and multiplication have little to do with success in Algebra, and that, after all, Algebra is the chief criterion of success in Algebra.

In a study just completed, the writer, from a slightly different approach, has gathered data on this subject from his Algebra class at Western Reserve Academy, Hudson, Ohio. It was felt that the *early* stages of Algebra might possibly be more dependent upon previous attainment in Arithmetic, or that some particular Arithmetic ability might be more important than others. Another possibility was that the fundamental Algebraic skills, such as Algebraic addition and subtraction, might be depen-

dent upon Arithmetic addition and subtraction, and so on. In other words, in forming the basis of a remedial program, was any one fundamental skill in Arithmetic of more importance than others for Algebra?

The class upon which this study was based numbers thirty-one boys in the ninth grade. The tests given them were as follows:

Beginning of the year

1. Terman Group Test of Mental Ability—Form B.
2. The Woody-McCall Test in Mixed Fundamentals of Arithmetic—Form I.
3. Monroe's Diagnostic Tests in Arithmetic, Parts II and III.

End of three months of Algebra instruction

1. Hotz's First Year Algebra Scale—Equation and Formula, Series B.
2. Hotz's First Year Algebra Scale—Addition and Subtraction, Series B.

End of six months of Algebra instruction

1. Hotz's First Year Algebra Scale—Multiplication and Division, Series B.
2. Hotz's First Year Algebra Scale—Problems, Series B.

The test given at the beginning of the year showed the median I. Q. of the class to be 114. On the Woody-McCall Arithmetic test, 53% of the class was above the norm for the end of grade 8 (corresponding to the beginning of grade 9.)

On Monroe's diagnostic tests in Arithmetic, the percent above standard ranged from 26% to 40%.

At the end of three months of instruction in Algebra, 76% of the class was above the norm for that time on Hotz's test on the equation and formula. On Hotz's test in Algebraic addition and substraction, however, but 33% was above standard for the end of three months of instruction.

At the end of six months, but 10% was above the norm for that time on Hotz's test on Algebraic multiplication and division. On the Hotz test for problems 60% of the class was above the norm at the end of six months.

Correlations were then worked out by the rank difference method, with the following results as shown in tables 1, 2, and 3.

TABLE 1.

Hotz's First Year Algebra Scale—Equation and Formula, Series B, at end of three months of instruction in Algebra

vs.

the following Arithmetic tests given at the beginning of the year:

Woody-McCall Test in Mixed Fundamentals—Form I		$r = .30$
Monroe's Diagnostic Tests:		
	Test 7 (addition of integers)	$r = .11$
	Test 8 (multiplication of integers)	$r = .32$
	Test 9 (subtraction of integers)	$r = .15$
	Test 11 (division of integers)	$r = .13$
	Test 12 (addition of fractions)	$r = .36$
	Test 13 (subtraction of fractions)	$r = .06$
	Test 14 (multiplication of fractions)	$r = .39$
	Test 16 (division of fractions)	$r = .08$

TABLE 2.

Hotz's First Year Algebra Scale—Addition and Subtraction, Series B, at end of three months of instruction in Algebra

vs.

the following Arithmetic tests given at the beginning of the year:

Monroe's Diagnostic Tests:		
	Test 7 (addition of integers)	$r = .00$
	Test 9 (subtraction of integers)	$r = .14$

TABLE 3.

Hotz's First Year Algebra Scale—Multiplication and Division, Series B, at end of six months of instruction in Algebra

vs.

the following Arithmetic tests given at the beginning of the year:

Monroe's Diagnostic Tests:		
	Test 8 (multiplication of integers)	$r = .27$
	Test 11 (division of integers)	$r = .21$

It may be noted that in every case the correlation is low, the range being from .00 to .39. According to H. O. Rugg (Rugg, H. O., "Statistical Methods Applied to Education," p. 256. Houghton Mifflin Co. 1917):

Correlation is negligible when r is less than .20
Correlation is present but low when r is .20 to .40
Correlation is marked when r is .40 to .60
Correlation is high when r is above .60

Let us now proceed to a closer examination of the results. In the first place, the class was above average in mental ability but barely average in Arithmetic achievement at the beginning of the course. At the end of three months it was slightly above the average on equation solving. In the light of the correlations obtained in Table 1, it would seem that some Arithmetic is needed, of course, in Algebra. When a student has passed through the Arithmetic of grades one to eight inclusive, however, success in the first three months of Algebra seems but very slightly dependent upon previous attainment in Arithmetic.

Furthermore, no fundamental ability in Arithmetic is outstandingly significant for success in Algebra. The highest correlation of .39 was obtained between multiplication of fractions and Hotz's test on equations. It is interesting to note also that if the thirteen correlations were listed in descending order, the

three correlations for multiplication (Arithmetical) appear among the highest five. There is a possibility that multiplication may therefore be slightly more correlated with Algebra than the other Arithmetic abilities. But the correlations are still low, and if the factor of intelligence is considered, it does not seem that any particular fundamental Arithmetic ability is of primary import in regard to success in Algebra.

It should be noted that the class was doing well in equation solving and in problem solving but poorly in Algebraic addition, subtraction, multiplication, and division. Likewise, the class was not as high in Arithmetic fundamentals at the beginning of the year as its mental ability might indicate. The question arose as to whether there might not, then, be a closer connection between fundamental Algebraic manipulations and Arithmetic fundamentals. The correlations shown in Tables 2 and 3 show, however, little relation even in the fundamental operations; that is, addition and subtraction in Arithmetic are little connected with success in Algebraic addition and substraction.

The writer feels that the satisfactory results in Algebraic equation and problem solving but poor results in Algebraic addition and subtraction are probably due to the increased emphasis upon the former in the newer type of text-books.

Another approach was possible to the problem here presented by virtue of the fact that this class is being instructed under a plan of individual progress. Each student proceeds with the next unit assignment as soon as he satisfactorily completes the one previous. At the end of the first three months, the students were ranked according to the number of "units" completed. The correlation of the Woody-McCall Arithmetic Test with the Algebra units completed was but .21, which also showed practically no relation between class progress in Algebra and Arithmetic achievement at the beginning of the year.

These facts are of practical value in many cases where beginning Algebra students have not had good achievement in Arithmetic. To be sure, intelligence is of prime importance in Mathematics, but there seems to be little evidence that one is doomed to have difficulty with Algebra merely because he had little success with Arithmetic.

The next question to be considered is, when should the remedial Arithmetic be introduced in the Algebra class?

The answer to this question is partially given in the previous discussion. If Algebra were closely dependent upon Arithmetic,

then the Algebra teacher should certainly devote much time at the beginning of the course in remedying deficiencies in Arithmetic. Since this does not seem to be the case, however, the Algebra teacher may either carry on a remedial program throughout the year, concomitantly with the instruction in Algebra, or else disregard the Arithmetic deficiencies entirely.

It would seem that the Algebra teacher should make an effort, however, to overcome deficiencies in Arithmetic. In the first place, to do so is a desirable educational aim. In the second place, the ninth grade will probably be the last grade in which any teacher will make a comprehensive effort to overcome the deficiencies that have not been mastered in the first eight grades. If there are Arithmetic deficiencies which are not corrected in the ninth grade, it is doubtful if they ever will be.

Very briefly, then, our conclusions are as follows:

1. Success in the initial stages of beginning Algebra, as well as final achievement in Algebra, is little dependent upon previous attainment in the fundamentals of Arithmetic.

2. No one fundamental ability in Arithmetic seems more important than others for success in solving equations in Algebra.

3. There is little relation between achievement in the fundamental skills of Algebra and Arithmetic, such as between Algebraic addition and subtraction and Arithmetical addition and subtraction, or Algebraic multiplication and division and Arithmetical multiplication and division.

YEAST TO REPLACE BEEF.

At the recent Swampscott meeting of the American Chemical Society, Dr. Little hinted at a revolutionary change in agriculture in the possible replacement of beef cattle by yeast plants. "Whereas it requires about 100 pounds of foodstuffs to produce three pounds of beef and three acres of land to support a cow, thousands of pounds of solid yeast protein can be developed and separated in a few hours in a very limited space from molasses and many other wastes containing fermentable sugars. That the yeast plant may be given more duties to perform in the near future than making bread and beer is evident from other papers. Dr. Charles E. Bills told of the preparation from yeast of a white crystalline compound called "ergosterol," which is one of the new hard words that the public will have to learn some time, although it is so far unfamiliar even to chemists, and they are not yet agreed on its pronounciation. The British chemists' present accent it on the third syllable and the American on the second. But the newcomer is important, whatever they call it, for it can be converted by the rays of the sun or mercury arc lamp into Vitamin D, which keeps babies from growing up with bow legs and poor teeth. This is the first of the vitamins to be made artificially and is so pure and potent that the addition of one part in a billion of the food will prevent rickets.—*Science News-Letter.*

GRAPHICAL DETERMINATION OF THE DISTANCE BETWEEN TWO GIVEN POINTS ON OR NEAR THE SURFACE OF THE EARTH.

By Alexis M. Uzefovich,

Cartographer, Rand, McNally & Co., Chicago.

The Need.—Geographers, mariners, aviators, radio-operators, teachers, students, and others, frequently encounter a problem which requires the determination of the shortest distance between two points the geographical co-ordinates (longitude and latitude) of which are known.

The Problem.—The shortest distance between two points is represented mathematically by the shorter arc of the great circle joining the two given points. Spherical trigonometry formulas provide a method for determining the length of the arc sought to any desired degree of accuracy, the result being derived by the regular solution of a spherical triangle, wherein two sides and the included angle are known. The unknown third side of the triangle represents the distance in question.

Unless a high degree of accuracy is required this problem may be solved by direct measurement on a well made globe, or by certain graphical methods[1] which give greater precision.

Geographical maps and charts will also give satisfactory results for distances not exceeding about 500 miles. For greater distances than 500 miles, however, the error becomes too large,[2] because:

1. The surface of the earth, being spherical, cannot be represented on a plane exactly in proportion, and all geographical maps represent the true outlines with more or less distortion, the degree of which depends on the choice of projection. Unfortunately, the majority of maps and atlases seldom indicate the system of projection, although such (a datum) is in fact just as important as is that of the scale. Mercator was among the first to call attention to the importance of such information.

[1]Journal of the Washington Academy of Sciences, No. 17, Oct. 19, 1924, offers several methods for this purpose ("A straight line chart for the solution of spherical triangles").

[2]For example: the distance between New York and San Francisco trigonometrically computed, is 2568 statute miles. The same distance measured on a map (230 miles to one inch, polyconic projection) is equal to 2527 s. m. The use of geographical maps for determination of distance between two very distant points (Panama-Singapore, Asia, Panama-Darwin, Australia) would give not only erroneous results, but will lead to a wrong conclusion. Looking at the World's Map (Mercator's projection) on which America is placed near the left end and the Old World near the right end of the map, one may get an impression that Singapore is nearer to Panama, than Darwin, Australia. Calculations, or graphical methods will prove the contrary: Panama-Singapore 11867 m., Panama-Darwin 10352 m. In case that America is located in the middle of the map, and the Old World is cut by two halves placed at the right and left ends of the map, it seems that the distance Panama-Calcutta, India, is more than Panama-Singapore. The real air distances are: Panama-Calcutta—10114 s. m., Panama-Singapore—11867 s. m.

2. The scale on the map is not constant, and, generally speaking, varies from one point to another. The scale along one or some lines—the meridians, parallels or certain other curves—is the same as the scale used for decreasing the globe as the basis of the projection, and is called the **Principal Scale.** In all other directions the scales are smaller or larger than the Principal Scale and such scales are called the **Particular Scales.** The smaller the difference between the principal and any particular scale, the more perfect is the projection.

3. The shortest distance between two points on the surface of the earth (an arc of the connecting great circle) will usually not correspond to the straight line drawn on the map between the two given points, but *will be represented on the map by a curve.*

Central Projection.—The sole exceptions to this rule are the maps compiled in *central perspective projection.* These projections, which are the oldest known ones, were first used by the celebrated Greek philosopher Thales (639-548 B. C.). The point of view is at the center of the sphere, and the plane of projection is a tangent plane, touching the surface of the earth at some chosen point. Central projections are sometimes called *gnomonics,* and they alone possess the exclusive and remarkable property, that all the great circles of the globe are represented on the projection by straight lines.

Central perspective projection is used mostly for celestial maps in order to represent the whole sky. The sky is projected on six sides of a cube circumscribed around the sphere, touching both poles and four equidistant points on the equator. In this projection the outlines of constellations are well preserved and the apparent courses of shooting stars will appear on the map as straight lines. Furthermore, this property of central projection offers the advantage of easy determination of the location of the radiant of shooting stars by continuing the courses in reverse direction until all of them intersect in one point—the radiant.

The method mentioned above is used also in the construction of terrestrial maps.

Charts constructed by gnomonic projection, on which the arcs of great circles are represented by straight lines, are especially important in navigation (great circle sailing charts).

Applying the Method.—Suppose now that the distance between two points A and B is sought. Let the geographical

co-ordinates of these points be respectively: Lat. 50° N., Long. 85° W., Lat. 30° S., Long. 25° E.

Take two cards: No. 1 and No. 2 (see Figs. 1 and 2). On card No. 1 draw a circumference of convenient radius, and call the center C. With a protractor divide the upper semicircumference into degrees of arc from the point E (0°) to Q (180°) through N (90°), and the right lower quarter of the circumference from E (0°) to S (90°).

The straight line EQ represents the *equator*, and the points marked N and S—the north and south poles respectively.

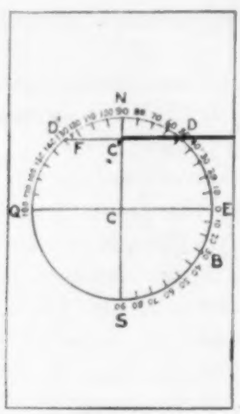


Fig. 1

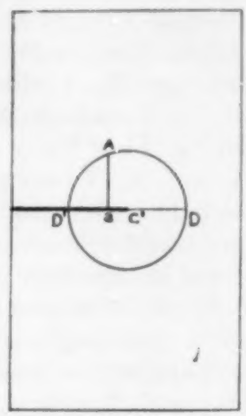


Fig. 2

Fig. 3

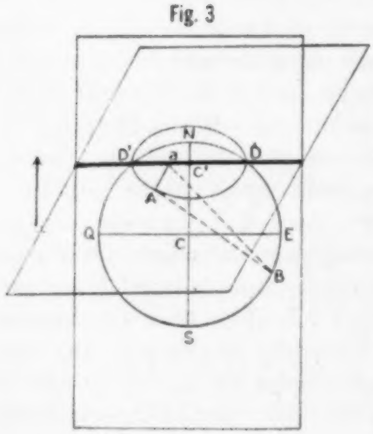
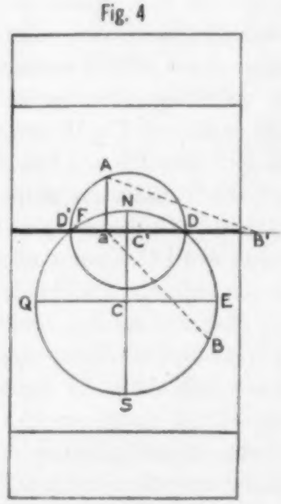


Fig. 4



Through the point corresponding to the latitude of the point A (50°N) draw a straight line DD′, parallel to EQ. In a similar way we will locate the point corresponding to the latitude of the point B (30°S), marked 30° and located on the lower part of the circumference.

Now take card No. 2, and draw on it a circumference of radius C′D equal to ½ DD′. The diameter of this circumference DD′ will represent the diameter of the 50th parallel in our scale. Mark the center of this circumference C′, and protract from the point D toward the point D′ the arc DA equal to 110°, i.e., the difference of longitudes of the given points (85°W+25°E=110°).

Now through the end of the arc marked A draw Aa perpendicular to the diameter DD′.

Cut the card No. 1 with scisors, through the line DC′, and the card No. 2 through the line D′C′. The proper cuts are shown on Fig. 1 and Fig. 2 by heavy lines.

Insert card No. 2 through the cut of card No. 1 with their planes at right angles (see Fig. 3). The points A and B will be placed in a proper relative position on the sphere. Indeed, point A is located on the 50th parallel of the northern hemisphere; point B on the 30th parallel of the southern hemisphere; the difference of their longitudes is the arc DA, equal to 110°.

Let us imagine two straight lines (see Fig. 3), the first one connecting point B with point a and the second one connecting point B with point A. These lines in addition to the line Aa will form a right-angled triangle AaB. The hypotenuse of this triangle AB is a chord of the arc of the great circle passing through the two given points A and B, and is the *shortest distance* between them on the surface of the earth.

By rotating the front end of card No. 2, as indicated by the arrow on Fig. 3, we will place the card No. 2 in the same plane with card No. 1, as shown on Fig. 4. Now let us take a compass and place its point at the point B and the other on the point a. Leaving one leg of the compass to stand on a, rotate the compass until the point of its other leg meets the diameter DD′ (or its extension) on the point marked B′, as shown on Fig. 4. Note, that aB′=aB. Retaining now the point of the compass on B′, place its other point on A, and you will find that the distance AB′ (Fig. 4) equal to AB (Fig. 3) is the hypotenuse (chord of the great circle). Carefully retaining on the compass this same opening, place its one point on E (Fig. 4) and rotate it until its other point meets the upper part of the circumference (of radius CE) at F.

Thus, the arc EF, representing the distance of our problem, is found. In the particular case in hand the point F will coincide with the point located on the upper part of circumference, marked 125° (see Fig. No. 1 and 4). Taking into account that one degree of the meridian is approximately equal to 69.1 statute miles, we find by simply multiplying 125 by 69.1, that the distance between the two given points A and B is equal to 8638 statute miles.

Illustrative Examples.—The following examples fully illustrate the essentials of the graphical method, just described:

Suppose a radio-station located at Chicago desires to find the shortest (aerial) distances to: 1—Los Angeles, California; 2—Nome, Alaska; 3—Oslo, Norway; 4—Melbourne, Australia.

Their geographical co-ordinates and their differences of longitudes in relation to Chicago, Ill., are as follows:

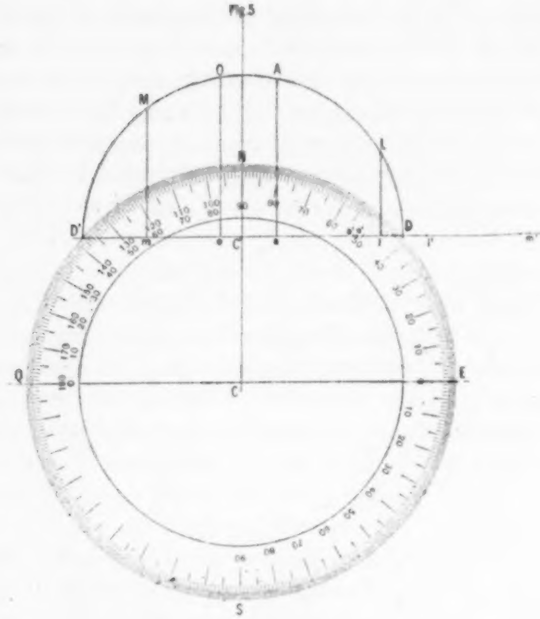
	Lat.	Long.	Difference of Longitudes
Chicago	41°50′N	87°40′W	0°00′
Los Angeles	34°03′N	118°15′W	30°35′
Nome	64°30′N	165°30′W	77°50′
Oslo	59°55′N	10°45′E	98°25′
Melbourne	37°50′S	145°00′E	127°20′

Draw a circumference of convenient radius. Divide the upper semicircumference into degrees: from E (0°) to Q (180°) through N (90°), and in the right lower quarter from E (0°) to S (90°). See Fig. 5.

If we choose as the length of the radius of the circle on Fig. 5 about 2½ inches, the circumference can be divided into parts equal to ½ of a degree, thus permitting readings to be taken with an error not exceeding 15 minutes of arc (reading by eye to one half of each division), which is approximately equal to 17 st. miles. If, however, we choose the length of the radius equal to 7 inches, the circumference can be divided into parts equal to ¼ of a degree, and, reading by eye to one third of each division, we have a maximum error of approximately 6 st. miles.

To save the time of drawing the circle and protracting it into degrees and fractional parts, one may well purchase a cardboard protractor of desired size and erase from it all figures which are not required (see Fig. 5).

Let the plane of Fig. 5 represent the plan of the meridian passing through Chicago. Points N and S will correspond to



AIR-LINE-DISTANCE-METER

the north and south poles respectively. The straight line which connects D and D′ and passes through the points on the circumference marked 41°50′ and 138°10′ will represent the diameter of the parallel passing through Chicago. On the line DD′ with it as a diameter, draw a semicircumference DN′D′, calling the center C′. On this semicircumference protract the following arcs from D (the differences of longitudes): DL 30°35′ for Los Angeles; DA 77°50′ for Nome; DO 98°25′ for Oslo; DM 127°20′ for Melbourne.

Draw through the points L, A, O and M perpendiculars to the diameter DD′. Call these perpendiculars Ll, Aa, Oo and Mm respectively. Then mark on the circumference of the radius CE points corresponding to the latitudes of the given cities.

Los Angeles—34°03′N; Nome—64°30′N; Oslo—59°55′N; Melbourne—37°50′S.

Place one leg of the compass on the circumference at the point corresponding to the latitude of the first chosen city (34°03′N. for Los Angeles, etc.). The other leg of the compass should be placed at the foot of the perpendicular relating to the same city on line DD′.

Retaining the point of the compass on the base of the perpendicular on line DD′, rotate the compass in any direction until its other point is set on the line DD′ or on its extension (Fig. 5). In this way the sections of line ll′, aa′, oo′ and mm′ will be found, each for the respective city. Continuing, with the point of the compass placed on l′ (or a′, etc.) place the other point on L (or A, etc.). The distance now included between the points of the compass l′L (or a′A, etc.) is the chord of the great circle passing through Chicago and Los Angeles (or Chicago-Nome, etc.). With the compass set for the distance l′L (or a′A, etc.) place one point of the compass on point E (0°) and rotate it until its other point crosses the upper semicircumference (of radius CE). The arc hereby included between the points of the compass is the arc of the great circle which was sought. Thus:

for the chord l′L, 25°15′
for the chord a′A, 48°00′
for the chord o′O, 58°30′
for the chord m′M, 139°45′

Taking one degree of the great circle approximately equal to 69.1 statute miles, and one minute—1.15 statute miles we find that the actual distances are: Chicago-Los Angeles, 1745 statute miles; Chicago-Nome, 3317 statute miles; Chicago-Oslo, 4043 statute miles; Chicago-Melbourne, 9657 statute miles.

The same distances between these cities found by computation according to formula of spherical trigonometry are: Chicago-Los Angeles, 1741 statute miles; Chicago-Nome, 3314 statute miles; Chicago-Oslo, 4040 statute miles; Chicago-Melbourne, 9668 statute miles.

The degree of precision was accomplished by the use of a 5 inches diameter protractor. By using a protractor of a larger size greater accuracy could be obtained.

Using a protractor of 7 inches radius we find by this graphical method that the distance between New York and New Orleans is 1174 statute miles and between New Orleans-Los Angeles, 1674 statute miles.

The same distances according to the "Table of air line distances," Department of Commerce (Bureau of Navigation, Radio Division) are: New York-New Orleans, 1173 statute miles, New Orleans-Los Angeles, 1,675 statute miles.

The Air-Line-Distance-Meter.—From what has been said above it is possible to give a general rule for using the "air-line-distance-meter" (see Fig. 5).

1—Through the latitude of the first given point[3] draw a line parallel to the equator, and on this line describe a semicircumference with radius equal to ½ of this line. On this semicircumference protract an arc (from right lower end of the semicircumference) equal to the difference of longitudes of two given points, and from the end of the protracted arc draw a perpendicular to the diameter of the above-mentioned semicircumference.

2—Using a compass, measure the distance from the degree of latitude of the second given point to the foot of the perpendicular, and keeping one leg of the compass on the latter point (the foot of the perpendicular), place its other point (rotating the compass in any direction) on the diameter of the circumference or on its extension. Keep the leg of the compass on this point, place its other leg on the head of perpendicular (the end of the arc equal to the difference of longitudes of two given points). Carefully retaining the opening of the compass, place one of its legs on "0°"; its other leg placed on the upper part of the circumference of our "air-line-distance-meter" will show some number of degrees. This number multiplied by 69.1 will give the shortest distance between the two given points in statute miles.

Special Advantages.—The two most valuable properties, which this method possesses are simplicity and rapidity.

The problem was solved in four movements of the compass and only once was its initial opening changed. Therefore, we are justified in expecting a high degree of freedom from the common errors, which occur in mathematical computations. Moreover, the rapidity of this method makes it very useful as a means of control, especially in cases where a number of distances between points are to be determined.

The author of this article has recently completed the task of determining the "air-distances"[4] between a number of cities located throughout the world. This included the determination of more than a thousand arcs. All of them were calculated by the spherical trigonometry formulas and this graphical method, used for the control, proved to be of great help.

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[3]If both given points are in southern hemisphere, the "air distance meter" can be used in the same way as for the points in N. hemisphere.

[4]Distance as measured on the surface of the earth differs so slightly from aerial distance, up to an altitude of five miles, that a correction factor is unnecessary for practical purposes. The allowance is made also by taking the earth as a sphere instead of spheroid.

NATURE'S GREAT AND SMALL AND MAN'S MEASUREMENT OF BOTH.

By Wm. T. Skilling,
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Part II. Radiation.

In no line of science has there been more progress and interest during the last few years than in that of radiant energy. Millikan has been experimenting with "cosmic rays," which seem to have their origin somewhere outside of the solar system—perhaps outside of the stellar system. Michelson has been redetermining the velocity of light, and a host of experimenters have been trying to gain better control of that similar but coarser form of radiant energy which we know as radio waves.

These and other forms of ether radiation such as heat, ultra violet light, X-rays, and the gamma rays emitted by radium are all of the same nature, differing only in frequency and wave length. They correspond with each other as the various notes along the keyboard of a piano are related. The short, tightly stretched wires at the right hand end of the piano vibrate faster, and send out through the air sound waves of shorter length than do those at the left. If we compare the very lowest rumbling sounds of the pipe organ or piano with radio waves, the bass notes of a little higher pitch would represent dark heat radiation. At about the comparative location of middle C is one octave of ether vibrations which is capable of producing light. That is, our optical nerves are adapted to this rate of vibration—this wave length.

Ultra violet radiation according to the scale we are using would be in the soprano range, X-rays among the high notes touched by the concert soprano, and radium rays too high on the keyboard to be reached by the voice. Cosmic rays occupy the highest place in the rays of frequency and have therefore the very shortest wave length. Referring to our sound analogy they would resemble the tinkle of the last notes on the piano, or the almost inaudible squeak of an insect's wings.

Long ago scientists began measuring the wave lengths of light of the various spectral colors by reflecting the light from a "grating." This is a bright metallic surface marked with about fourteen thousand parallel lines to the

inch, made with the point of a diamond. The grating makes a spectrum, and the position that lines of certain wave length occupy in the spectrum bears a certain relationship to the distance apart of the grating lines. Knowing the spacing of the grating lines, and the position of spectral lines their wave lengths can be calculated.

To make a spectrum it is necessary that the distance between the lines of the grating be not many times greater than a wave length of the light being used. X-rays failed to produce a spectrum when tried upon the ordinary grating.

Since X-rays were too delicate to be measured by anything so coarse as a grating of fourteen thousand lines to the inch, Professor Laue of Munich conceived the happy idea of trying a natural grating whose lines, he reasoned, would be closer. Crystals, such as rock salt, for example, are made of atoms lined up like soldiers on a parade ground. Naturally lines of atoms would be closer than any artificial scratches. Crystals were tried with the X-rays, and they worked. They gave about a ten millionth of a millimeter as the wave length of X-rays. This is more than a thousand times as short as light waves.

The gamma rays of radium were soon measured by the crystal method and found to be ten times shorter than X-rays. These stood at the foot of the class of ether radiation for several years, until Dr. Millikan began to investigate the cosmic rays which were found sifting in upon the earth from all directions.

Cosmic rays are of too short wave length to be measured by even crystal gratings, but fortunately the penetrating power of radiation gives a means of estimating its wave length. The so called "hard" X-rays, of short wave length, penetrate quite a thickness of metal, and an operator must be protected by lead plates through which they cannot pass. The "soft" X-rays, whose waves are longer, are more easily stopped.

Instruments for the detection of cosmic rays have been lowered to great depths in mountain lakes, and from the power of the rays to penetrate the water their wave

length has been found to be a hundred times shorter than those of radium.

The cosmic ray, therefore, is at one end of the scale, and the radio wave, which in some of the Naval radio stations is several miles long, is at the other end; one the cricket's chirp, the other the organ's rumble.

As in sound, wave length and frequency of vibration of the sounding body are so related that knowing one gives means of finding the other, so it is with ether vibrations. Middle C (with the tuning used in physical laboratories) has a vibration rate of 256 per second, and its wave length, found by dividing this into the velocity of sound is about four feet. Similarly C in the bass with half the frequency gives a wave length of about eight feet, while the highest C note on the keyboard with a frequency of 4096 gives a wave length in air of about three inches.

Transferring this method to the realm of ether vibration, where the velocity is three hundred thousand kilometers per second gives enormous quantities for the rates of oscillation which produce the waves.

In the case of radio waves of the broadcast band, which lie between two hundred meters and six hundred meters in length, the oscillation rates are found by simple arithmetic, as above, to be from 1,500,000 to 500,000.

These waves are started by oscillations of the electric circuit in the antenna of the sender. Oscillations originating in atoms, such as those causing light, X-rays, etc., would be expected to be more rapid. The same method, dividing wave length into velocity, gives six followed by fourteen ciphers as the wave frequency of yellow light. Fifteen figures are needed to express the frequency of light waves while only six or seven are needed for radio frequency.

Like Kipling's "Explorer," who was driven on by the thought of "Something lost behind the ranges," so the research man of today is leaving behind him the well trodden paths of science and is projecting himself forward and upward on the wings of his cunningly devised apparatus and the winds of his imagination. Beyond the

ordinary reaches of heat and cold some of our leading scientists have, during the past few years, gone in both experimentation and theory. Professor Onnes in his laboratory in Leyden, working with liquified helium came nearer to the point of absolute cold than had ever before been reached. He arrived at a temperature at least within one or two degrees of that almost unattainable condition in which molecular motion ceases entirely, that is, at two hundred and seventy-three degrees below the freezing point of water.

An Arctic explorer is content if he *finds* the pole, and is not likely to linger long to study conditions there. But Onnes having practically reached the pole of absolute zero which he was searching made some observations which have excited wide spread interest.

Most notable among the effects observed around in the neighborhood of absolute zero was the behavior of an electric current in a thoroughly cold conductor. Many metals lose their power of resistance to the flow of electricity when thus chilled, so that a current once started continues almost indefinitely without further aid from the battery.

A ring of lead was placed in the very perfect refrigerator and a current started in it by induction. For six hours while the lead was kept cold, the current continued with scarcely perceptible lessening. It was estimated that it might have continued to flow for two years if the cold had been maintained.

At the other end of the temperature scale the range of investigation has been more varied for the range of temperature is wider. Though temperature has a lower limit of two hundred and seventy-three degrees below freezing it has no upper limit. As long as any more violent motion of the molecules is possible the temperature can go higher. Moissan's electric furnace gives a temperature of about three thousand, eight hundred degrees, but Anderson, by sending the full charge of his mammoth condenser of a hundred large glass plates through an iron wire raises it to about twenty-five thousand degrees; of course vaporizing it in the process.

It was thought that possibly a temperature could be

attained that would shatter the atom, breaking up iron for example into elements of smaller atomic weight. But nothing of the sort occurred as shown by the spectrum of the flash. The iron was ionized, that is, a few of the atom's outer electrons were knocked off, but the nucleus itself, which represents the individuality of the electron, was not changed. The nucleus is a tough customer.

Besides artificially producing heat of extremely low and high temperatures great progress has been made in the investigation of the natural sources of heat, the sun and stars. Instruments of almost unbelievable sensitivity have been invented for the detection of heat.

As long as only the sun was the object of investigation the "pyrheliometer," a blackened silver plate, used by Dr. Abbot of the Smithsonian Institution, served as a sufficiently sensitive heat detector. Abbot's only trouble was in finding how much of the sun's heat never reached his detector because of being absorbed by the atmosphere. To overcome this obstacle he took readings at various elevations and thus estimated that at the top of the atmosphere nineteen and four-tenths large calories fall every minute upon each square meter exposed perpendicularly to the rays of the sun). This amount is the same winter and summer.

Of late, the measurement of stellar radiation, a more exacting task, has claimed the attention of several research men. Delicate electric instruments indicate and measure the heat coming from a single star. Abbot uses a fly's wing, for lightness, as the detecting element in his radiometer. One of the first instruments for use with stellar radiation was so sensitive that it indicated the heat coming from the face of a man two thousand feet away, who was assisting with the experiment.

A heat detector called a thermocouple is used at the Mt. Wilson Observatory in connection with the one hundred inch reflecting telescope, the largest in the world. The needle of the galvanometer which is a part of this apparatus would be moved by the heat from a candle one hundred and twenty miles away if the heat could come through empty space avoiding absorption by the air. With this thermocouple Drs. Pettit and Nicholson

have measured the heat coming from Betelgeuse, Sirius, Antares, Arcturus, and several other stars. They concentrate all the light entering the one hundred inch telescope from a single star upon the absorbing thermal element, which is about the size of a period in print. A current is set up by the warmth, and the needle moves.

Measurement of surface temperatures of the sun and stars is possible because of several effects which temperature produces. The color of a star, for example, depends upon its temperature; so does its brightness; the amount of heat it radiates of course does; and, finally, the hotter the object the farther toward the blue end of its spectrum will be the point of maximum temperature.

These various effects make the determination of temperature possible by several methods. They all lead to very similar results and show that heavenly bodies are exceedingly hot. The sun's surface is at nearly six thousand degrees centigrade, and the stars vary from about two thousand degrees to about forty thousand degrees. These temperatures, except those of the cooler stars, are far above the vaporizing point of all of the elements. Compounds would be impossible except in the red stars and in sun spots, where the temperature is low enough to permit a few of the most refractory compounds to form. The presence of compounds is shown by the spectroscope.

As to what temperatures exist within the sun and stars only theory can give answer. But modern scientists do not build theories without a very good underpinning of experimental fact. So describing scientific statements as theoretical should not brand them as probably incorrect.

One of the greatest of modern theories has been worked out largely by Dr. Eddington, of the University of Cambridge. It relates to the internal constitution of the sun and stars. Notable among other conditions existing there is the exceedingly high temperature. The violence of thermal agitation of the atoms which would be required to prevent condensation of gas to liquid is estimated to be equivalent to a temperature of forty million degrees at the center of the sun.

Some of the stars, known technically as "white dwarfs," are thought to have had their atoms stripped of all or many of their revolving electrons. This has allowed the nuclei to pack more closely, giving great density to the substance. One such star, known as the companion of Sirius, has an average density of twenty-five tons to the pint.

Though such a conception would have been considered ridiculous a few years ago it is now rated a very probable and natural condition. It is based upon the following facts. Since an atom, like the solar system, has nearly all of its mass concentrated at the center, and as atoms cannot approach each other so close as to cause interlocking of the electrons' orbits therefore remove the electrons and condensation is almost unlimited.

What might not a temperature of forty million degrees or more do toward shaking loose the electrons? To be sure temperatures approaching those within the stars cannot be attained terrestrially, but Millikan and Bowen have stripped one entire "shell" of electrons, seven in all, from chlorine atoms. They used for the purpose the energy of an electric spark with an instantaneous voltage of twenty-five thousand, and current of one thousand amperes.

EINSTEIN UPHELD.

Einstein's theory of relativity still stands. The Michelson-Morley experiment, which many years ago failed to show an expected motion of the earth through the ether of space, and led to the relativity theory as an explanation, still fails to show any such motion. At the meeting of the Optical Society of America Prof. A. A. Michelson, physicist of the University of Chicago and Nobel prize-winner, announced the final results of a repetition of his classic experiment.

Working at the Mt. Wilson Observatory in Pasadena with much improved apparatus, capable of detecting a motion as much as 2 per cent. of that expected, none was found. The very slight effect found was less than that to be expected by experimental error and not more than a tenth of what he found before.

Physicists hail this announcement as showing that Prof. Dayton C. Miller, of the Case School of Applied Science in Cleveland, was mistaken in supposing a few years ago that he had found such an effect, though smaller than originally expected. So far, however, they are unable to explain the source of Prof. Miller's error.—*Science News-Letter.*

THE FUNDAMENTALS OF SCIENCE.

A Basic Subject for All College Courses.

By J. H. Simons,

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Preliminary Outline.

It is a common opinion among those interested in education that improvements could be made in the treatment of elementary subjects in college. Much effort has been made in this direction in the various orientation and coordination courses that have been tried out of late years. Some measure of success has been achieved in these efforts in the social sciences and kindred subjects, but the effort in this direction in the natural and exact sciences has not met with any great enthusiasm. The general science courses that have been devised have been almost wholly a mass of interesting biological and other descriptive material, and as such may have some place in education, but this place is not in college.

The need of some change in the teaching of elementary science courses in the college and university is felt by three groups: scientists and the teachers of science, educators and school administrators, and the students and former students.

Each scientist is aware of the faults in the teaching of his particular science and so thinks that more effort and time should be expended upon that subject and usually is of the opinion that for the general advancement of culture all students should be introduced to that particular science. The teacher of science shares these views but also understands the difficulty of teaching enough in the elementary courses to be of much help. At least half of their effort on these courses is expended upon matters which should precede the study of any science and without which no science has any considerable meaning. The two most common difficulties of the teacher of elementary chemistry and physics is the student's lack of ability to use the English language carefully and accurately and the lack of arithmetical ability. Of a more subtle nature is the lack of ability to use or even appreciate the use of a logical method of thought. This handicaps the teaching of science in a very large measure.

Educators and school administrators are confronted with the fact that, although more and more time and money is expended upon the teaching of the various sciences, the demands of each science continue to increase and the net result is not

satisfactory. For a well rounded education some elementary work in most of the branches of science would seem necessary in the present age, but this is impossible due to the time required. The taking of an elementary course in one or two sciences may meet science requirements for a degree, but surely suggests a one sided education especially as most science teachers are almost wholly interested in their particular branch.

Students whose interests or ability fit them for the study of one particular science are retarded or bored by the teaching effort that is necessarily expended upon matters not directly pertinent to that branch. Those who take several elementary science courses for the cultural value are confronted with the necessity of learning much of the scientific technique of each branch without getting the general philosophy of the science, which is their aim. Former students realize that, although such and such elementary science courses were taken, very little value from these is retained in later years.

The solution of this problem is complicated by the various specific interests and prejudices of the numerous people involved. Let us assume that it could be solved by a properly designed coordination course which would precede all further work in any branch of science and which would be taken as a required subject by all freshman students. Of course, the entire curriculum of science studies would of necessity be revised.

In order to be of value such a course must show enough of the scientific philosophy to give the student an appreciation of it, must drill in the scientific method of thought, must show the similarity between all branches of science, must cover that material which is common to them all so that this should not have to be duplicated in each department, and must show enough of the diversities of science so that anyone desiring further work will know in which branch he would have the most interest and ability. If this could be accomplished, the work of teaching the elementary details of any particular branch of science would be greatly simplified, and work that is covered in one year in the elementary courses could easily be covered in one-half to one-quarter of the time. It would be well for any student starting out to study some one science to appreciate the relationship of that particular department to the whole of science. For the cultural student the particular cataloging of the sciences at present has little meaning.

From an educational point of view the purposes of such a

course would be: first, to drill the student along the lines of materialistic logic as contrasted to purely philosophical reasoning for the purpose of better living in this materialistic universe; second, to orient the student to his materialistic surroundings; third, to develop an appreciation for science and scientific philosophy; fourth, to lay the foundation for further work along scientific or other logical lines; and fifth, to prevent students who have little or no capacity for logical thinking from further work requiring this. In order to fulfill these purposes the course should be constructed so that it will attempt to develop in the student an ability for exact logical reasoning, to create the ability for exact expression both written and oral, to train him in observation, to enable him to be both rapid and accurate, and to develop in some slight measure the method of acquiring knowledge through the hands.

It is obvious that general science courses and courses in which a series of lectures on various topics are given by experts in these lines, will not fulfill these aims. Their great wealth of heterogeneous facts immediately defeats these purposes.

The student entering the university has had a considerable memory training and a training in expression which tends toward verbosity and cloudiness rather than pointed exactness. His observational ability is poor and frequently the educational opportunities through manual activity have been neglected. To accomplish the purposes and aims as outlined above with this material requires more than just a series of lectures with an examination thrown in occasionally. It requires constant and daily drill under expert supervision. The student should be given a fundamental course in development of these abilities that are desired rather than one of interesting content.

It is my belief that many more students could be trained to reason logically and to enjoy the benefits of this reasoning than do at present, provided there were an adequate method of training. Any material will be interesting to the student provided he be required to gather the data himself and actually do the reasoning. People are always interested in things which they can think about, and a student's interest can always be held as long as you can keep him thinking.

As the aims of the course are not facts and subject matter, but rather a fundamental training in a certain kind of logic, the content should be taken from simple, every day, materialistic, and easily observed phenomena. Anything involved which is

not immediately perceived should be treated by the method of using analogies of things with which the students are familiar. The facts of science are so enormous that it is impossible to make much progress from a content standpoint in one small course, and it is likewise impossible to satisfy the prerequisite content requirements of the present advanced courses in the various sciences; but a student who has had this fundamental training will be able to absorb the contents of the various sciences much more readily than one without it. Much more content can be put in the various science courses that follow this basic course and so the required ground can be covered before graduation perhaps better than it is now. In this course a minimum of descriptive material should be used and this from the entire field of science. It is not to be expected that a homogeneous course can be made by sandwiching small slices of the various sciences together, although this is the method that has been used in most coordination courses. Every branch of science should be called upon to contribute material to support, illustrate, and assist in the realization of the fundamental aims of the course, but the philosophical basis should not be subordinated to the requirements of any of the particular sciences. Obviously, the content of the course must be taken, especially in the beginning, from those simple every day phenomena in which there are only a few variables acting and which are commonly called physical. The more abstract and imaginative chemistry and advanced physics and the elaborate and monumental masses of highly classified knowledge of the biological sciences must come later and in a measure be subordinated.

All science is a tendency toward simplification and so all the material should be presented as simply as possible; trying to avoid confusing the students with the many complicating details which lead numerous people away from the simple underlying principles. The cataloging of our knowledge into the various sciences and branches of these is a purely arbitrary matter and should be ignored for the purposes of this course.

The method of reasoning should be inductive rather than deductive; and, in order that logic and exactitude shall be the basis, a minimum of material should be committed to memory. It should be stressed that that which is memorized should be retained exactly and not approximately. This is difficult for it is directly contrary to the almost universal listlessness and

lack of concentration and the vagueness and inaccuracy of memorized material.

Some students do not have the capacity for logical reasoning, but these should not be classed as university grade and they would be eliminated in this course either by giving out under the weight of the work or by failing in it. Students satisfactorily completing the work should be in a much better position for further study because of the training. This course would tend to dissuade mediocre students from continuing in scientific lines.

The following outline has been made by analyzing science for its fundamental concepts and then organizing these in a logical manner. Almost any desired descriptive material can find a place in this outline, for, as the philosophy of science is the basis, all descriptive material must fall within its range.

As the portion on classification does not fit in any particular place in the logical scheme, it could be handled at any time. It might even be made to run along parallel to the philosophical development. In this latter manner it could be made to supply much of the necessary descriptive material.

Many of the terms used in this outline have a specific meaning in some particular branch of science, especially in physics, besides a general or philosophical meaning. In all cases it is the general and not the specific meaning of the term that is meant. It is also to be understood that the outline is for the purpose of organizing the courses and should not be given to the students as an outline. All the possible or even desirable illustrations of the concepts and principles are not shown in the outline nor is all the desirable or necessary descriptive material pointed out. This would all come as the course is developed.

The author recognizes that this course treated in a somewhat different manner would be very desirable for advanced students in science in order to get the relations of the branch in which they are specialized to the whole of science. For these people it would be very valuable as a course in scientific philosophy.

The suggested method of handling this course is to have at least five or six meetings of the students a week. A lecture will be necessary perhaps once a week in order to bring the material together, to stimulate the students, and to present material and demonstrations that can not economically be treated in any other manner. The daily work should be divided into three parts. In one part the teacher will bring out the

subject by close questioning of the students. This shall not be done by formal and lengthy recitation, but by active discussion. It is not intended that the teacher should lecture but develop the logic from the students with a series of short questions and answers. Another part of the time should be spent in a written exercise of the type which is built to develop reasoning and expression. Essay type of questions should not be asked, for they tend toward vagueness, but rather pointed and short questions. The daily written work will tend to check up the students and stimulate continued activity. The third portion of the time should be spent in laboratory work in which the information is obtained by the student. The student must be required to obtain the data necessary to solve a certain problem without being told just what data to obtain. In other words, the "cook book" type of laboratory work is not desired. The laboratory experiments must be supplemented by a set of very close questions, so that the student is at all times mentally in command of his work, and not doing things just because the book says so. Their technique should be closely watched and constantly corrected, for the sense perceptions obtained through the fingers are just as good as those obtained through any other sense.

The physical equipment of the laboratory must be so designed that physical, chemical, biological experiments, etc. can be done in the same laboratory.

It would seem necessary that the sections be made small and that the teachers be especially selected for the work.

In the outline there are nine general headings. These are then divided into a number of different parts and where necessary the divisions are then subdivided. The general headings are numbered and the divisions lettered.

1. The most elementary concept is that of material objects, the idea of mass or matter.
   A. The introduction of this subject will show the universe as a function of matter.
   B. Coarse visual objects with their differentiation and measurements. Dimensions and size.
   C. Immense objects such as world features and the heavenly bodies. The use of the telescope and other instruments. Restricted vision of such objects and the properties implied from the observation or properties of restricted area. Reasoning from the properties of a part to the whole.
   D. Fine grain objects. Mixtures. Additive properties of mixtures. The difference in property of a group of objects with that of the individuals as the difference between a forest and the individual trees.

E. Microscopic objects. The use of a microscope. The idea of the relativity of size.
F. Solutions. These are developed as intimate mixtures.
G. Composition of objects in terms of substances. Many objects made of the same substances. Simplification by analysis.
H. Ultimate composition (atoms, ions, molecules, electrons).
I. The states of matter.
Fluid, solid. Gas, liquid, crystal. Mixtures of states. Relativity of the states of matter shown as a function of temperature.
J. Form composition (crystal forms, cells, parts of plants and animals, disperse systems).
K. Density and the concept of intensive properties. The use of measurement and calculation.
L. Concentration. This is similar to density. Percent composition. Calculations of concentration and composition.

2. The concept of force or pressure follows as a relation of objects.
A. The introduction to this concept will show that pressure is the static reaction of one object on another.
B. Physical pressure or weight is the simplest example.
C. Fluid pressure, hydrostatics, and wind pressure.
D. Mechanical advantage. Levers and simple machines, biological examples. The use of linear relations in calculations. The relation of calculations to the physical universe.
E. Attraction.
Gravitational, molecular (cohesion, adhesion, crystal forces, surface tension) physical examples.
F. Gas laws. Another example of the relation of simple calculations to the universe.
G. Action at a distance.
Sound, Electrostatics, Magnetism, Radiation, Light (color).
H. Sex attraction in simple organisms.
I. Strength, that is to resist pressure. Forms for strength, biological examples.

3. The abstract concept of potential or tendency. The concept of motion as the unhindered operation of a force.
A. Introduction showing potential as the cause of force.
B. Differences in head, potential levels or states. Relativity of potential. Use of arbitrary reference in things which are relative.
C. Temperature and its relation to molecular motions. Effects of temperature, biological, geological, etc.
D. Momentum, force in motion.
E. Potential as a cause of flow.
Heat, current electricity, fluid flow.
F. Potential as a cause of biological changes, fertilization, motion, nerve reactions, etc.
G. Concentration changes, caused or causing potential. Effects of this in nature.
H. Escaping tendency, vapor pressure, etc.
I. Speed or velocity of motion. The concept of time is introduced here for it is only known in relation to velocity.
J. Chemical reactions as caused by chemical potentials.
K. Storage which is the preserving of some potential. Storage of motion or flow, potential energy; storage of food in plants and animals.

4. The concept of inertia.
A. This is introduced as the resistance to the operation of a potential or of a flow or motion.
B. Friction and electrical resistance as examples of inertia.
C. Other examples of inertia in nature which can even go so far as mental inertia.

D. Inertia as a continuance or lack of change.
E. The measurement of inertia.
F. Inertial bodies—gyroscope, heavenly bodies, etc.
G. The relativity of motion.
H. Continuance of meta-stable conditions. Examples of this, glass, steel, seeds, and eggs.
I. Reproduction in kind, cell division, reproduction of individuals.
J. Friction machines, boats, aeroplanes, etc.

5. The concept of consistency or of orderliness, and its use in classification.
   A. The introduction should develop the idea that nature is consistent and orderly and that logic is the perception of this orderliness or the making of things mutually consistent.
   B. Nature in infinite variety and gradual gradations.
   C. Classification as to shape or size.
      Examples, crystals, minerals, stars.
   D. Classification as to form.
      Examples, plants, animals, earth features.
   E. Classification as to properties.
      Examples, the chemical elements in the periodic system, the classes of chemical compounds, fungi and bacteria.
   F. Classification as to composition.
      Examples, chemical compounds like salts of one kind, foods, etc.
   G. Classification as to time (chronology).
      Examples, geology, archeology.
   H. As a conclusion to this rather heterogeneous topic the simplicity of nature in the ultimate analysis should be shown.

6. The concept of conservation.
   A. Introduction showing conservation as a sort of inertia in the larger sense, a persistency of fundamentals. This is reflected in our mental opposition to spontaneous creation and the beginning of time. Large time cycles in nature.
   B. Conservation of mass.
   C. Conservation of particular kinds of mass.
      Examples, in chemical reactions, the quantitative relations in science, chemical equations, etc., biological cycles in nature.
   D. Conservation of topography.
   E. Conservation of momentum. Demonstrated in periodic motions and collisions, etc.
   F. Conservation of energy. The chief basis for the concept of energy is in conservation and so the energy concept is developed at this point. The forms of energy. Radiations.
   G. Energy measurements. More use of calculations.
   H. Energy machines, heat engines, etc., radio.
   I. Periodicity and frequencies.
      Examples in nature, light, etc.
   J. Plant and animal energy relations.
   K. Life and life histories (biological).
   L. Cosmic evolution.

7. The concept of chance.
   A. This is defined as equal opportunity under an unknown law.
   B. Demonstrated in coin tossing and simple games.
   C. Probability with examples.
   D. Molecular kinetics.
   E. The rate of occurrence of a natural event as a chance phenomenon.
   F. Spontaneous reactions.
      Example, radio activity.
   G. Life statistics.
   H. Life chance and propagation rates.

I. Mandelian law and heredity.

8. The concept of equilibrium.
   A. Equilibrium shown as action and reaction, checks and balances.
   B. Physical equilibrium and stability.
   C. Chemical equilibrium and the factors influencing.
   D. The effects of a change of conditions on equilibrium and the laws governing, the principle LeChatelier.
   E. Steady states as a form of equilibrium.
      Examples of steady states.
   F. Biological equilibriums.
      Ecological equilibrium.
      Struggle for existence.
   G. Geological equilibrium.

9. The concept of change.
   A. This is shown to be the tendency toward an equilibrium or the operation of potential to overcome inertia.
   B. Change toward complication.
      Examples, growth, chemical evolution, geological change.
   C. Change toward simplification.
      Examples, decay, geological change and erosion, chemical change.
   D. Principle of entropy, a contradiction of the concept of conservation.
   E. The philosophical conclusions from the concept of change and entropy, the paradoxical situation and the solution.
   F. Variety of kind (biological) as change to get into equilibrium with the environment.
   G. Organic responses such as irritability.
   H. Organic evolution with as much detailed biological information as is necessary included here.
   I. The evolution of scientific theories.

INDIANS NEGLECTED JEWELS.

Native Americans, who preceded the white man in the possession of this continent, seem to have made little effort to mine the treasures in their reach, according to Dr. George F. Kunz, well known authority on precious stones. Although diamonds have been found in thirty-five localities in the United States, they were never worked by prehistoric Americans. With all the gold in California, there was no gold mined or worked by Indians of that particular region. It was the Spaniards who really set the Indians to hard labor in the search for precious stones and metals.

How public opinion can help or hinder the progress of American archaeology is pointed out by Dr. Carl Guthe, of the committee on state archaeological surveys of the National Research Council. There is considerable digging among American antiquities by amateurs and traders who do not realize that the old pottery, beads, and other relics are really parts of important historic documents, Dr. Guthe said. Removing such things from the soil without first carefully recording all evidence as to their age and significance, and then making collections out of these isolated specimens is about as useful as cutting the "ands" out of valuable old manuscripts and marveling at the different penmanship of the old writers. The great importance of archaeological expeditions is not the collections they can make but what new things they can learn about the past civilizations of the world. Public opinion condemning the practice of spoiling American antiquities for science would be more powerful than legislation he said.—*Science News-Letter.*

MATHEMATICAL PROBLEMS IN ELEMENTARY CHEMISTRY.

By W. G. Bowers,

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The amount and character of mathematical work to be given in connection with elementary chemistry has been a problem to the chemistry teacher for many years. When high school teachers first realized that chemistry was unpopular with certain philosophical students, they concluded that the remedy was in the placing of more mathematics in connection with the text book work. When high school authorities saw fit to make high school work as practical as possible, the idea of mixing many mathematical problems with chemistry was advocated. When leaders in the field of education saw the necessity of teaching students to think rather than to learn things by rote, chemistry teachers jumped at the conclusion that a great deal of mathematics in connection with the work solved their part of the problem. These ideas all seemed to strike the chemistry teachers about the same time. Between 1904 and 1912 such leaders as Newell[1] and Morgan[2] were strongly advocating the use of many problems in connection with the study of chemistry.

About the year 1910, the popular texts contained rather large lists of mathematical problems. For example: Brownlee, Fuller and Others contained in the chapters on,

Gas volume	13
Molecular Composition	3
Molecular and Atomic Weights	8
Symbols and Formula	16
Equations	6
Sulfur	8
For the remainder of the chapters on the different elements	22

The teachers of chemistry soon found themselves swamped in the mathematics of chemistry and even mathematics having not much to do with chemistry. Segerblom[3] sensed the situation immediately and advocated the use of problems which developed a knowledge of chemistry only. About the same time Alexander

[1] School Science and Mathematics, Vol. 9:661-65 (1909).
[2] School Science and Mathematics, Vol. 8:645 (1908).
[3] School Science and Mathematics, Vol. 10:18-21 (1910).

Smith advocated the same thing and carried the point a little further by suggesting some rules of pedagogy by which chemical problems could be solved easily and yet not be solved in such a way as to cause them to lose their value in developing the student's knowledge of chemistry. Smith calls attention to the fact that two problems may be exactly alike excepting one may pertain to animals and the other to atomic weights. The biologist can easily see through the former, the chemist the latter. Smith recommends that problems for the beginner in chemistry be put first in a familiar setting and then carried over into the chemistry. He recommends in the second place that the problems be simplified to involve as small numbers as possible at first and then carried to the more complex forms. He says at all times and in all cases make the problems extremely practical. These facts show that the mathematics phase of the problem was serious at that time. Some text book authors in order to solve the problem left mathematics out of the books altogether. Vinian's "Every Day Chemistry" published in 1920 has no mathematical problems in it. Brownlee, Fuller and Others "Chemistry of Common Things" has only six problems in the whole text. Weed's "Chemistry in the Home" has a couple of elementary science problems.

The above facts would make it appear that the authors of text books were at that time trying to get away from mathematical problems entirely. Then when the classroom teacher remembers the saying of McMurray, "the beginning of any good thinking is a problem in a student's mind which to him is worth solving," and when he thinks of Dewey's philosophy of education in the sciences, when he advocates a problem in connection with every topic and a problem that grows out of a situation in life; he clamors for problems in connection with the chemistry of common things, and chemistry in the home. Of course all classroom teachers did not put the same interpretation on problems, and all did not know what interpretation these men would have put on the term problem in chemistry.

Text book authors have been justified in thinking that one way to make the study of chemistry a series of problems is to mix plenty of mathematics with it. Since some authors advocate stressing practical information, we now have some popular texts having in them no mathematical problems whatever. Those who advocate stressing practical problems as well as those who advocate stressing the fundamental theory, have

generous lists of mathematical problems. For example:

Gray, Sandefur and Hanna, the text used in our own training school offers about 65.

McPherson and Henderson give from two to four at the end of almost every chapter, about 100 in all.

Newell gives from four to eight at the end of almost every chapter, about 200 in all.

The writer realizes that mathematical problems are not the only kind of problems that are connected with the study of chemistry. He also realizes that they are by no means the most important kind. They are, however, a very beneficial kind if the right type and the proper number are placed in the most logical connection with the other types of work.

In the first place problems that involve mathematics and chemistry should not be made with the idea of developing mathematical principles. Lists should not be built up with the idea of passing from simple to complex as far as mathematics is concerned. The mathematics should all be as simple as possible and the outstanding purpose of the problems should be elementary chemistry absolutely.

When we say elementary chemistry absolutely we mean a few of the elementary fundamental principles and a few of the elementary practical applications. Surely we could not hope to aid students in learning to solve problems involved in every fundamental principle underlying Inorganic Chemistry, as it should be offered to high school students. The calculations that are necessary for the building of a formula when the percentage composition is given is very fundamental but it is not simple enough to satisfy beginners' curiosities, nor is it practical enough to hold their interest. The same could be said of the calculations involved in the determinations of molecular weights when the amount of the lowering of the freezing point is given.

There are a few calculations that the beginner is curious about and will be interested in until he has mastered the principles. These come in connection with his laboratory work. The unavoidable condition is, too, that he has to work in the laboratory with problems involving these calculations, for several weeks before he can learn the chemical principles by which the problems can be solved.

Two of the types of calculations referred to are those involving volume relations and those involving the estimation of quantities required in certain reaction. It would appear to be

unfortunate that the most logical arrangement of laboratory exercises involve a type of problem which cannot be solved until the student learns how to write equations and apply proportions to them. Under these circumstances the best thing the teacher can do is to explain to the student that he will continue to have such problems without their growing more complex until he learns enough about balanced equations to learn a method of solving the problems. For most students this idea serves to intensify the interest in the mathematical part of the problem until his anxiety serves as a great aid in the solution in the mathematico-chemical problem when it does conveniently come. He wonders about the mathematics, and finds when it comes it is mathematico-chemical, and is elated to see that he has learned some practical chemistry.

To illustrate the point, one of the first experiments given to the student is one that will exemplify the differences between a compound and a mixture. The student is directed to weigh out 4 grams of sulfur and 7 grams of iron. He cannot help but wonder why the 4 and the 7, and he invariably asks the instructor. Rather than introduce the formula which is so fundamental and important, i. e., atomic or molecular weight of one substance is to atomic or molecular weight of another substance reacting with it, as their real weights are to each other, it is better to merely say this is the definite proportion by which these elements combine, and if you should weigh accurately the four and the seven and make the chemical combination there will be no surplus of either in the container. This will be a pertinent answer according to the purpose of the experiment. Then it may be added that later the method of finding the real weights that will react will be studied.

The preparation of oxygen from potassium chlorate, generally causes the student to wonder how he could find out exactly how much of the chlorate to use in order to fill four 500cc bottles. The instructor can explain again that lessons will be given on that later, but now the purpose is to test the properties of oxygen.

By observing the attitudes of the students in their laboratory work it may be found that mathematical problems involving quantities required for reactions and those involving gas volume and weight relations, are the only types that should receive attention if satisfying curiosity and holding the interest of the students are the chief things to consider in the construction of a course in elementary chemistry. In this case even the rela-

tions of volume to temperature and pressure need not be considered.

If the study of fundamental principles is considered to be the important thing regardless of what appeals most to the class of students, these are the only types of problems that could be used to advantage. Any mathematical problems that would pertain to the theory of ionization would be too technical and difficult. Any that would pertain to speed of reaction would be entirely out of place. Any that would pertain to the theory of solutions would be too difficult and impractical. Furthermore, the mathematical problems involved in quantities required for complete reactions, are sufficiently related to the atomic theory, atomic and molecular weight relations, equivalent weight relations, and valences, to serve the purposes that are supposed to be served in connection with instruction in regard to these most fundamental theories.

As to the number of problems to be offered it would seem as though it might become monotonous to impose on the student more than a half dozen of each type. There are, however, many varieties of the type dealing with reacting quantities. The variety is not in the mathematics. The mathematics can be reduced to a simple proportion in every case. Even the case of four grams of sulfur to be used with seven grams of iron can best be put in form of proportion, At. Wt. S....At. Wt. Fe = R. Wt. S:R. W. Fe, or 32:56 = 4:7. The variety does not exist so much in the fact that the reacting substances are sometimes elements represented by atoms and sometimes compounds represented by molecules, and sometimes both, but it exists in the application of the formula to various equations in their balanced form. In order to get the student well enough acquainted with each variety of application to make the problem serve its purpose, there should be about as many mathematical problems in the course as there are laboratory exercises.

Another important question is, should the problems come in connection with the text book work and be discussed in class or should they come in connection with the laboratory work? The introduction of a new general type should be given in class. The close observer will soon find that to do more than this is to waste time for the reason that the students cannot see what it is all for. There should be just as many problems connected with the laboratory work as are necessary in the laboratory work. Therefore the mathematical calculations should be

performed in connection with the laboratory work. When the student goes to the laboratory to make 1,000cc of carbon dioxide he must calculate how much sodium carbonate and how much sulfuric acid will be required. If it is found to occupy too much of the student's time at the beginning of his laboratory exercise and to take the instructor's attention from other students when they should be getting started, all students should be asked to make the calculations for their next exercise before they come to the laboratory to begin the next exercise. If that is done, students will look ahead and if they find they will need no help on the next calculations they will leave them to perform independently at home or elsewhere. If they find they need help they will avail themselves of it before leaving the laboratory.

As to any particular methods of dealing with these problems, there is not much to be said. The most difficult part of course is to get the equation balanced. The student often gets the attitude, if I must solve this problem someone must show me how to balance the equation. So the teacher must ever be impressing the student with the fact that to learn chemistry he must learn to balance equations, and that the mathematics is the practical application of what he learns.

The instructor needs to constantly watch to see that the student makes the proper application of the proportional formula to the balanced equation. He generally has four parts to the equation and four to the proportion and he wants to substitute in numerical order. He must be reminded that the third and fourth term in the proportion has nothing to do with the equation, that the equation is balanced and has four or more parts only to find the ratio of the atoms or molecules involved in the two substances in question. After the student gets right on these relations, he has no trouble substituting in the formula and solving the mathematics of it.

To summarize the points we have tried to make:

1. The mathematics connected with elementary chemistry should be as simple as possible.

2. The mathematical problems should deal only with gas volume relations and reacting quantities.

3. There should be as many problems as are necessary to drive home and make practical each variety of chemical reaction with which the beginner deals.

4. The problems should be taught in such a way as to develop a knowledge of chemistry rather than of mathematics.

THE CORRELATION BETWEEN MEASURES OF MENTAL ABILITY AND MEASURES OF ACHIEVEMENT IN CHEMISTRY.

With Suggestions for Improving the Accomplishment of Superior Students.

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Mental ability tests or tests of intelligence have been used extensively in the schools as a basis for classifying pupils and as aids to supervisors and administrators in diagnosing the difficulties which pupils have with their work. In summarizing in regard to their usefulness Pintner states that "classification in homogeneous groups (on the basis of scores on mental ability tests) is justifiable because intelligence correlates highly with school success and therefore the more homogeneous the group the more likely are the children to advance together at about the same rate, be that rate relatively fast, normal or slow." This[1] statement implies that there is rather marked agreement between valid measures of achievement and these measures of mental ability. Thus far most of the statistical studies of this relationship have been made with elementary or junior high school subjects. Almost no studies of the relationship to ability in chemistry have been reported.

This paper reports correlations between scores on intelligence and various measures of achievement in chemistry. The achievement measures include scores on so-called standardized chemistry tests, teachers' marks and marks on the New York Regent's Examination. Most of the data have been obtained from a cooperative study conducted by the chemistry teachers of North Eastern Ohio Chemistry Teachers Association.[2]

The Terman Group Test of Mental Ability was given to the students in chemistry in five Ohio high schools; 222 pupils were tested. Intelligence Quotients (I. Q.s) were computed from the scores. These pupils are referred to below as Group A. The Powers General Chemistry Test, Form B, was administered to these pupils at the end of the course. In a large school, referred to as Group B, the Cleveland Intelligence Test was given to 222 pupils. The Probable Learning Rate (P.L.R.) of each pupil was computed from his score. This corresponds approximately with

[1]Rudolph Pintner, Intelligence Testing, Henry Holt & Co., p. 230.
[2]Test scores were supplied through the courtesy of Miss J. C. Bennett, East High School, Cleveland, Ohio.

I. Q. A student with P.L.R. of 1.00 is expected to make normal progress. The same chemistry test was given to those students at the end of their course. In a third school, referred to as Group C, the Otis Group Intelligence Test was given to 193 students. The Index of Brightness (I.B.) of each student was computed from his score. An I.B. of 1.00 indicates ability to make normal progress. These students were also tested at the end of their course with the Powers General Chemistry Test, Form B. The degree of relationship between the measures of mental ability and of achievement is given as the coefficient of correlation (r). The Pearson Product Moment formula was used in the computation. The significant data are shown as Table I.[3]

TABLE I.

Median and Sigma scores on Intelligence Tests and Chemistry Tests and the Coefficients of Correlation between Measures of Mental Ability and Achievement.

	Intelligence Test			Powers Chemistry Test		
	Cases	Median	Sigma	Median	sigma	r
Group A	222	109.6(I.Q.)	10.44	40.7	10.26	.31±.06
Group B	222	106.0(P.L.R.)	13.86	27.0	8.82	.46±.04
Group C	193	120.4(I.B.)	21.00	29.7	10.44	.67+.03

Fifty of the students of Group C were given Gerry's Test for High School Chemistry in addition to the Powers Test and the teacher of these students has submitted his final marks. Inter-correlations between raw scores on Otis Test and the various measures of achievement, and the teacher's estimate of achievement are given in Table II.

TABLE II.

Inter-correlations of Otis Test Scores, Chemistry Test Scores and Teacher's Marks (50 cases).

	Otis Test	Powers Test	Gerry Test	Teacher's Marks
Otis Test		.399±.08	.35±.08	.03±.095
Powers Test			.81+.03	.53± .07
Gerry Test				.409±.08
Powers & Gerry Test	.38±.08			. 35±.08

[3]Data which is comparable to that contained in Tables I to IV is given in the following articles of Contributions to Education, Volume 2, World Book Company, 1928:—Max Smith, A Comparative Study of Four Chemistry Tests given to College Students, pages 182 to 199; Max Smith, A Comparative Study of Chemistry Tests with High School Pupils, pages 200-210.

In another school the same measures were used except that the Terman Group Test of Mental Ability was used instead of the Otis Test. Similar results were obtained as shown in Table III. The Terman raw score was used in these calculations.

TABLE III.

Inter-correlations of Terman Test Scores, Chemistry Test Scores and Teacher's Marks (36 cases).

	Terman Test	Powers Test	Gerry Test	Teacher's Marks
Terman Test		.41±.09	.38+.09	
Powers Test			.538±.08	.588±.07
Powers & Gerry Test	.46±.08			

In one of the New York City schools the Terman Group Test of Mental Ability and the Powers Test for General Chemistry and the New York Regent's Examination were given to the same students. Inter-correlations between these measures are given as Table IV.

TABLE IV.

Inter-correlations of Terman Test Scores, I. Q.'s, Chemistry Test Scores and Scores on the Regent's Examination.

	Powers Test	Regent's
Terman Test Scores	.26±.099	.44±.085
I. Q.'s	.32+.095	
Powers Test		.35±.06

The data of these tables seem to suggest that there is but little relationship between the measures of mental ability and of achievement obtained from the use of these tests. Before attempting to interpret the data of Table I it should be noted that the students of Group A were for the most part seniors in high school, Group B were sophomores and Group C were juniors. Group A (median I. Q. 109.6) and Group B (median P. L. R. 106.0) are quite similar in mental ability. It is reasonable to assume that the difference of 13.7 points on the achievement test in favor of Group A is in part, at least, due to the greater maturity of the senior group. However the intelligence level of Group C (median I.B. 120.4) is somewhat above that of either of the other two groups and they are more mature by one

year than Group B, yet the achievement of Groups B and C is nearly the same.

It would seem from these observations either that the achievement test is a less valid measure for Group C or that the accomplishment is not what it should be. It is entirely possible that the first of these alternatives is the true explanation. The value of r ($.67 \pm .03$) indicates for this group a closer relationship between the measures of intelligence and of achievement than for either of the other groups. The standard median on the Powers Test for General Chemistry for students who have had instruction covering the same period of time as these groups (one school year), is 35.

Data in Tables II and III give evidence of the validity of the achievement tests. The values of r, $.81 \pm .03$ (Table II) and $.538 \pm .08$ (Table III) indicate fairly good agreement between the results obtained from the two measures of achievement in chemistry. The correlation between scores on the achievement tests and teachers' marks indicates that the abilities measured by the achievement tests are, in considerable part, the same as those which are rewarded by the teachers.

The number of students considered in the computations of Table IV ranged from 40 to 53. From these data it appears that Terman Test scores are as good or better indications of ability to succeed on the Regent's Examination than scores on the Chemistry Test. This is an anomalous finding and entirely unexplainable, by the writer, unless it may be said that both values of r are so low that chance factors have determined them.

These results suggest an important question for the teachers and supervisors who are interested in the improvement of instruction. All the correlations are positive but they are low. We may conclude from this that intelligence as measured by the tests is a factor of success but within the range of ability of these students it is not a very important one. It is, indeed, likely that it is not as large a factor in successful attainment of marks as it should be. Detailed examination of some of the data lends support to this opinion.

A correlation factor may be low simply because there is no positive relationship between the two abilities which have been measured. If this were true of the two abilities in question, namely ability to score well on intelligence tests and ability to score well on chemistry tests, then it would follow that students who do poorly on intelligence tests would stand an equal chance

with all others to score well on chemistry tests. On the other hand there might be close relationship between the two abilities but the instruction such as to allow the native ability to remain dormant when it might if properly stimulated, be effectively used in the development of ability to score on the achievement test.

When the correlation is +1.00, as is the case, for example, when measures of temperatures on the Fahrenheit scale are correlated with measures on the Centigrade scale, the relationship between the two measures may be expressed by a straight line. Comparison of the pairs of measures of intelligence and of achievement used in the calculations reported as Table III shows that there is an approximation to this relationship for the students who are low on either test. But students of mental ability approximating that of the median are about as likely to score well on the achievement tests as are the students of superior mental ability. This suggests that class progress is set to the median ability and that superior students are not stimulated to use their talent. This is a likely hypothesis and if it is true, improvement of accomplishment from superior students will result from adaptation of instruction to the individual differences of the class. Specifically we should set higher standards for those of the class who are shown by the tests to have superior ability and demand the accomplishment of these standards. Comparison of the intelligence test scores and the teacher's marks assigned to these pupils lends further support to this hypothesis. There is a close relationship between the measures of intelligence and the marks assigned to pupils who are at or below the median in mental ability. Those above the median are almost without exception marked lower than is consistent with their ability. None were marked higher. There were nine students whose course marks were 70 or lower. Of these, three were in the lowest one-seventh of the intelligence distribution and five were in the highest four-ninths. *One of these was the most intelligent member of the class.*

Studies of pupil progress have shown quite conclusively that in general students who make high scores on the intelligence tests are able to make most rapid progress in school work. When such a condition prevails as the one just described, it implies that we are failing with our most capable students. The situation in the classes from which these measures were obtained is probably typical of what prevails commonly in

chemistry classes. The importance of the problem is evident for it appears that some of the best talent of our classes is being wasted.

It is not expected that intelligence shall be the only factor of success in high school chemistry. There is convincing evidence that the public school is increasingly selective on the basis of ability as the student progresses from grade to grade. Within the relatively narrow range which prevails in the eleventh and twelfth grade the factor of intelligence is of less importance as an attribute of success than in the lower grades where the range is wider. Within this limited range other factors of success in achieving marks are, determination to succeed; motivation, through recognition of need for learning in order to accomplish an ambition; physical well-being and home life conducive to study. Other factors are attractive personality and good looks. It is recognized that the correlation between achievement in chemistry and intelligence could hardly approximate $+1.00$ unless there is a closer relationship between mental ability and the traits just enumerated than is generally supposed to exist. However, of the many traits which make for success, it is likely that native ability is the most important, and progressive teachers and supervisors will lend their efforts to the perfection of methods of teaching and to the organization of a content of instruction which will stimulate pupils of highest ability to develop their talents. Under ideal conditions such as are suggested by these considerations it is likely, in fact it seems quite certain, that the factor which expressed the correlation between measures of mental ability and of achievement will be considerably higher.

STORMS CAUSE STATIC.

Thunderstorms are guilty of the production of the static that occasionally interrupts radio reception, especially in summer. They also cause the formation of cathode rays—the rapidly moving electrons or atoms of electricity that cause X-rays when they are stopped by a heavy metal. This is the opinion of R. A. Watson Watt, British government radio engineer. But even though this static is the bane of good radio reception, it has its use, said the speaker. The weather observer can use this to locate distant thunder-storms, and he told the scientists how he had developed a special form of radio direction finder for the purpose. An experimental receiver of this kind has been ordered by the U. S. Navy, he stated. Several years ago, when the U. S. Navy was experimenting with a receiver for getting weather maps on ships at sea, some similar experiments were made. The weather map receiver, the invention of C. Francis Jenkins of Washington, was attached to a direction finder, and the course of the tropical hurricane which later struck Miami was recorded.—*Science News-Letter.*

METHODOLOGY IN BIOLOGY.

BY VALEDA G. NORRIS, AND GEORGE W. HUNTER, PH.D.
Pomona College, Claremont, Calif.

The work in this paper was largely done by the junior author, that of the senior author being directive.

In an article[1] published last year, which set forth data obtained from investigations carried on in regard to methodology in biology, mention was made of lost questionnaire answers from the Wadleigh High School (girls). Several hundred of these papers were recovered, and were made available for this study by the senior author. In conjunction with this work the same number of questionnaire returns[2] from the De Witt Clinton High School (boys) were used for the purpose of comparison. The results tabulated and recorded herein are based upon the findings in these papers.

The questionnaire was sent to a number of selected schools where the same type of course was given to students of approximately the same age. For those not familiar with the method and plan used in the distribution of the questionnaires, attention is called to the detailed account given in the above mentioned article.

The following is a copy of the questionnaire sent to the various schools mentioned[3]:

School..........................Age..........................Sex..........................Date..........................

Do not sign your name. Be honest in your answers. Think what you want to say before you write it on the paper.

1. Have you always lived in this city? If not tell where you lived before you came here and how old you were when you came to live here.

2. Are you NOW interested in living plants or animals?

If so, tell how your interest expresses itself. E. G., if you are interested in pets, etc., this would be one way in which this interest would express itself.

3. Were you interested in plants or animals before you were twelve (12) years old?

4. Have you ever or do you now collect stamps, pictures, stones or minerals, flowers, etc.? If so, please tell how you became interested in this pastime.

5. In order of your choice (as 1st, 2nd, 3rd) name three topics which interested you most in your year's work in biology. Tell why these topics interested you.

6. Which way do you like to learn biology best? Put a check after your choice. Please give a reason for your choice.

(A) By experiment or laboratory work you did yourself.

[1] "The Problem of Method in Elementary Biology," SCHOOL SCIENCE AND MATHEMATICS, June, 1927.
[2] The required number (280) was selected at random from the available papers.
[3] "The Problem of Method in Elementary Biology," SCHOOL SCIENCE AND MATHEMATICS, June, 1927, pages 596-597.

(B) By demonstration or experiments performed by the teacher.
(C) By field or museum trips.
(D) By class discussions on assigned lessons.
(E) By reference or outside reading.

Let us consider question No. 6 which deals with the choice of method in the learning of biology. The age variation for the girls was from 12 to 17 and for the boys from 13 to 18, with the age medium in each case at 15 years. This is represented graphically in the accompanying figure (Fig. 1).

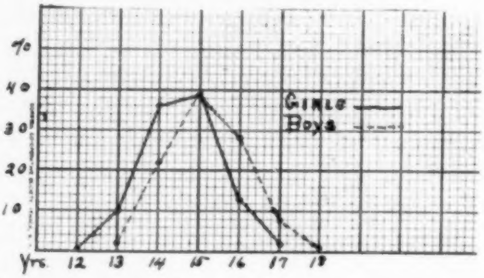


FIG. 1. CURVE OF AGE DISTRIBUTION (IN PERCENTAGE) OF PUPILS CHOOSING METHODS A, B, C, D, E, AND COMBINATION.

The division of choice as indicated by the answers gathered from the papers filled out by the 280 girls and the same number of boys is given in Table I, and the block graph (Fig. 2) represents the distribution by percentage.

TABLE I. CHOICE OF METHOD. (FIG. 2.)

	Girls (Wadleigh H. S.)		Boys (DeWitt Clinton H. S.)	
	No.	Per cent	No.	Per cent
Method "A"	49	18	61	22
Method "B"	76	27	69	25
Method "C"	82	29	30	10
Method "D"	30	10	45	16
Method "E"	2	1	2	1
Method Combination	41	15	73	26
	280	100	280	100

There is a marked difference in Method "C," with a slight rise noted in "A" and a decrease in "B" for the boys. The highest percentage for the girls is in the excursion method, and for the boys in Method "B," yet the percentage for the girls in the demonstration method is above that of the boys for the same method. The preference for Method "C" is comparatively strong at 14 and 15 years for the girls, but method "B" is noted to have a higher percentage than "C" at 15 years. This difference and comparison is apparent from Table II.

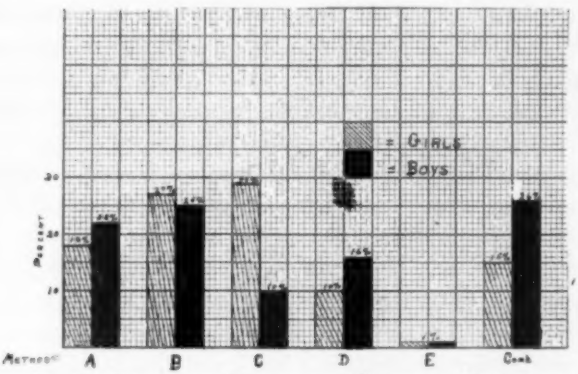


FIG. 2. BLOCK GRAPH OF CHOICE OF METHOD. BASED ON ANSWERS FROM 280 GIRLS AND 280 BOYS. A—EXPERIMENT OR LABORATORY WORK DONE YOURSELF. B—EXPERIMENTS PERFORMED BY TEACHER. C—FIELD OR MUSEUM TRIPS. D—CLASS DISCUSSION ON ASSIGNED LESSONS. E—REFERENCE OR OUTSIDE READING. COMBINATION OF METHODS.

Comparison with the choice of methods, taking ninth grade science in the De Witt Clinton high school, "School Science and Mathematics" volume 27, No. 6, page 598, is in a general way the same. The only great difference being that in combination of methods. How to account for this difference cannot now be determined.

TABLE II. A PERCENTAGE DISTRIBUTION OF THE CHOICE OF METHOD (BASED ON ANSWERS FROM 280 GIRLS AND 280 BOYS).

Methods / Age of Pupils	12		13		14		15		16		17		18	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
A	2	0	14	3	49	23	29	36	6	26	0	12	0	0
B	0	0	8	3	30	16	46	46	12	33	4	2	0	0
C	0	0	11	0	37	43	39	20	11	27	2	10	0	0
D	0	0	13*	2	33*	20	33*	40	20	29	0	7	0	2
E	0	0	0	0	0	0	0	0	100	50	0	50	0	0
Comb.	0	0	7	4	34	20	42	41	17	25	0	7	0	3

*Considered as $13\frac{1}{3}\%$, $33\frac{1}{3}\%$ and $33\frac{1}{3}\%$.

The most boys choosing Experiment Method "A" are a year older than the most girls making the same choice, whereas the age peaks are identical in the choice of demonstration or experiment performed by the teacher. The boys at 14 years show little decided preference, at 15 indicate Method "B" and a desire for the use of more than one method, and still hold strongly to the same at 16 years.

The greatest increase in choice for the Combination Method by the boys cannot be explained in full, but apparently the boys

felt more keenly the desirability of the use of more than one individual method. From an analysis of their reasons one may gather that there was greater interest and comprehension of subject matter gained through the presentation of material by the different methods used in combination.

In tabulating the choices under the heading "Combination," where a reason was given covering just one method that was listed under the individual method and only those without reason or reasons, and those which were sufficiently covered with a reason were recorded under Combination Method. In going through the papers it was found that the boys were more careful to give reason for desiring a joint method procedure than the girls.

The various combinations of methods which were more generally indicated are as follows: AB, AC, AD, BC, BD and CD. Some of the reasons are given below.

TABLE III. ANALYSIS OF CHOICE OF METHOD.

	Girls	Boys
Method "A"		
More interest in doing it alone	28	10
Easier to remember and understand	13	27
Convincing	6	3
Experience and practice		4
No reason	2	17
Method "B"		
More interesting and understandable	25	37
Correct performance	6	6
It is explained	14	8
Easier to remember	5	2
No reason	26	16
Method "C"		
Easier to remember and understand	36	13
More interesting	21	3
Liked outdoors	10	...
Learn to study for yourself	2	...
See foundation of nature's work, see real things	1	8
No reason	12	6
Method "D"		
More understandable	10	12
More information		9
Interest in discussion and arguments	12	13
"Cannot shrink from duty"		1
No reason	8	10
Method "E"		
Not so easily forgotten	1	...
Like to look up things and read	1	...
More interesting		1
Learn more		1
Combinations (Figures within brackets indicate the number of choices by girls, other numbers for the boys) "AB"—(3), 12. "AD"—(2), 5. "AC"—(9), 14. "ABC"—(1), 3. "ABD"—2. "ABE"—(1). "ACD"—2. "ACE"—1. "ABCD"—(1). "BC"—(10), 14. "BD"—(5), 8. "BE"—(2), 1. "BCD"—(1), 5. "BCE"—(1). "BCDE"—(1). "CD"—(4), 4. "DE"—2. Total	41	73

The following reasons[4] given for the different choice of methods indicate plainly a thoughtful consideration on the part of the girls and are interesting and worthwhile from a psychological standpoint in an analysis of activity interests.

An interest in working individually, though not much initiative in the experimentation, is shown in the choice of Method "A."

"I find that I learn things much better when I experiment them myself." "I believe it more." "I am eager for the results and it gives me great pleasure to see the different changes in the experiments." "I like that because you can prove what you are told."

In the choice of Method "B" we find the idea of correct performance and explanation coupled with a better understanding.

"Because it is better performed and it is made correct." "Because you see it done before you it always lingers in your mind." "Because when explained before you and by one who knows more than you do, you should understand it better." "The picture seems to rest in my mind." "The teacher understands fully the results and can explain as the experiments go along and can tell before time what to expect and how to get proper results." "More is learned by the teacher's careful experiment than by incorrect ones of the pupils." "It is an interesting way of proving the facts; I do not like assigned lessons and discussions because they are too dry and uninteresting, and much harder." "That was the only way I would be able to understand the work. When I did it at home, if there was anything I didn't understand, there wasn't anybody I could ask." "I like experiments best because in Biology there are things that are hardly believable, but by seeing it performed one may be sure that it is true."

One might at first attribute the picnic idea as the reason for the girls selecting museum and field trips, yet this is not borne out in light of the reasons.

"Seeing is believing." "Because I think things are understood better if seen than if simply studied out of books; then, I also prefer studying in the open air than indoors." "You see other things besides seeing what you go after." "One gets tired of the class room and we get some exercise and have a chance to see the things illustrated that are not in school." "Because I can remember what I see, if it is explained to me while it is before me." "When I learn it out of books it seems like a fairy tale." "When one sees things with naked eye one is bound to remember it." "Because I like to be in the air and find out things." "I like this because I enjoy going out in the fields and museums." "Because you can see things as they are, and can realize better what the study means to you. I love to study from real things, as I quickly put my thought on them." "You can see the real foundation of nature's work." "I think we would all understand and like it better were we to see things naturally and converse freely with our teachers instead of learning by rote some facts or opinions of our superiors." "One can study the live specimens, and not those grown faded and old in preservatives." "We are out of school and yet learning things we want to know, which are of great value to the education but very interesting."

The following are a few of the reasons given for the choice of the class discussion method:

"Because some points in the lesson which you have not noticed are brought out and you understand the work much better." "I like arguing

[4]A tabulation of reasons given by the boys was given in the previous study to which attention has been called.

with people." "The teacher explains the things we don't understand, and we are allowed to exercise our imagination."

Reference or outside reading was given preference by two girls with these explanations:

"Because I can think about it more and I do not forget it so easily." "I like to look up different things and read a great deal."

To supplement the above list we will include some of the reasons given for the selection of a combination of methods. The number making such choices is indicated in Table III.

"AB" Combination:

Girls: "Like to do the experiment myself or watch, because I like to see how the thing works out."

Boys: "Have a chance to find out things that you couldn't learn without experiments. Teacher helps you to understand things which you didn't understand before." A number of the boys expressed the feeling that through experiments the work was more interesting and more understandable.

"ABC" Combination:

Boys: "Learn more in laboratory and in field than from books and assigned lessons." "Teaches us to do things ourselves; better understanding; study of natural environment."

"AC" Combination:

Girls: "Somehow feel more interested in work and then I know that the things I read are true, and because you find new things and more interesting things." Experimenting by yourself you become more interested. By walking through field or museum your attention is drawn to peculiar things you would not see otherwise." "Makes it more interesting. See nature itself and how things really are." "Instructive, self confidence, reliability. Like nature."

Boys: "Remember better, more interesting. Pupils see the things in natural form." "When I do something I will believe it because I know it is possible for I myself to do it. Because I like to study the insects, animals, flowers, just as I see them in the fields and museum, while alive." "Experiments and laboratory work sticks in one's mind. We learn most from experience. On trips we see things before our eyes." "Because it draws you closer to the subject." "Don't forget experiments done by myself. Seeing certain plants I am more interested."

"ACE" Combination:

Boys: "I rather do experiments myself because it teaches me how to think for myself. I also learned a great deal by museum and field trips, because 'I actually saw things.' I also believe in doing outside readings as there are many things which are not done in the class room."

"AD" Combination:

Girls: "If work is done by a girl she remembers it better. If it is discussed in class can learn more and read at home." "Find out things for myself. Prove my point and find out why I am wrong."

Boys: "When you make experiments yourself you come across things which you would not if the teacher made the experiments for you. Class discussion is good because you get two sides of the thing."

"BC" Combination:

Girls: "Teacher would explain every movement she took. While searching for one thing quite probable other things would be seen which were explained." "Like to watch experiments prove true or false and I like to find plants in fields." "Experiments help you and are interesting. Helpful to find plants."

Boys: "Would give one a chance to see with his own eyes what is done." "If teacher demonstrates he brings out important facts and keeps the pupils interested. By field or museum trips because you see the things as nature produced them." "Because when demonstrations are done by

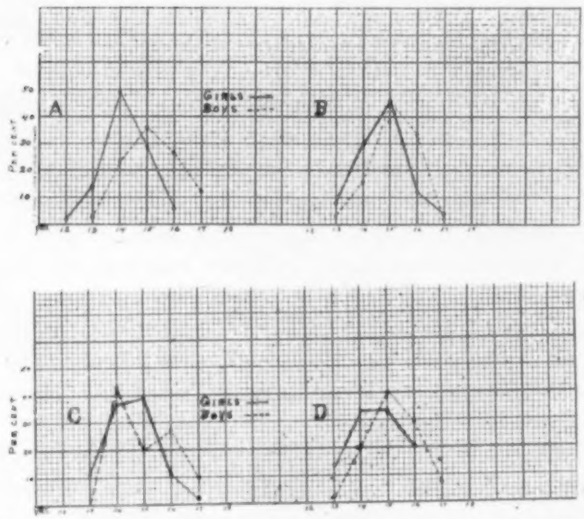


FIG. 3. AGE COMPARISONS WITHIN INDIVIDUAL METHODS.

the teacher you know they are right; when done by yourself you cannot tell. Because a field or museum trip when taken with a teacher, he explains everything." "By experiments performed by the teacher we learn how to perform these experiments ourselves, and also learn where things are used in order to perform them. By field and museum trips I actually see the things I am going to study about. See the way things live if they have life, etc." "I understand more about it when I watch the teacher perform the experiments. By 'C' I know more what I have studied and at the same time things that I don't know are also talked about."

"BD" Combination:

Girls: "Grasp the work more quickly. Interesting." "Interesting to watch the teacher work. Can't argue with book but can with the teacher." "She does them correctly and also makes interesting by explaining them as she goes along. Can give your own opinion also hear others."

Boys: "Learn more when you see somebody else do a thing and then try to do this yourself. Understand work better." "By discussions on assigned lessons one could understand the lessons better and by experiments you could be able to do experiments by yourself after seeing work done." "Can understand more when the instructor performs the experiment and the class discusses it." "Teacher tells us things which we could never find out ourselves. I learn the other side of the discussion of the subject." "If the teacher demonstrates and experiments, he can do it better than the pupil and the pupil understands more fully. He not only has his own opinion about a thing but he gets good points from some of the other pupils. Some outside reading and field or museum trips also add something to the pupil's knowledge of the things had or is to have." "It would show the boys that the thing is true which the teacher shows. I think one could get a better idea of the work when discussed in class as all the pupils would put their opinions on the subject."

"CD" Combination:

Girls: "See plants and animals in their natural environment. Gives opinions of all the girls, thus getting the correct answer." "See everything yourself and you write down about them. Teacher and pupils talk about the lessons and understand lesson better."

Boys: "When we went on a field trip I saw the flowers and bees themselves. While in class I saw only the pictures. When we were assigned some lessons from our Biology book, I could not understand many paragraphs and when it was discussed in class I found out what it really meant."

"DE" Combination:

Boys: "Don't like to write up experiments. I like to read a great deal."

If the curves for the four methods—"A," "B," "C," and "D"—are superimposed upon each other we find the highest percentage choices for "A" and "B" at ages 14 and 15 years respectively, with "C" holding a fairly even place through 14 and 15 years for girls. This in general agrees with the senior author's findings from a larger number of students in both city and rural schools.

For the boys at 14 years there is a decided rise for excursion method; at 15 the peak for "B" is highest and is the same as for the girls at 15 years; and methods "D" and "A" respectively claim second and third place.

The findings seem to indicate that sex differences cause differences in choice of method. In both findings of the previous paper and this paper, the girls prefer the excursion method. The careful analysis of the answers given by the Wadleigh High School girls by the junior author, gives their evident reasons for this choice.

These findings point to the fact that one single method is not to be considered as the most efficient way to conduct work in biology, and that the pupils have greater confidence in the value of the material studied, and seem to have a feeling of a broader understanding of the results sought and obtained when they are guided by a competent teacher in laboratory and in field work. They are not quite ready to launch out upon their own initiative and accept their conclusions as the desired results.

If we do not consider the high percentage in the Combination Method as a discrepancy we are inclined to supplement Method "B" with individual experiment work and excursions, not forgetting the value to the pupil of the opportunity to discuss with the teacher, as well as with other pupils, the subject matter presented through the different channels of approach and interest.

CHEMISTRY GROWING TOO FAST.

The chemical industries suffer from the rapid progress of chemical science. At the Nitrogen Symposium almost all the speakers took occasion to point out that the plants built during the war for the fixation of atmospheric nitrogen for explosives, like that at Muscle Shoals, were obsolete and incapable of competing with processes invented since. In the early and antiquated methods, meaning those of ten years ago, the chief requisite was cheap power. Now cheap hydrogen is more sought.—*Science News-Letter.*

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

University of Michigan, Ann Arbor, Mich.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, 204 Mason Hall, University of Michigan, Ann Arbor, Mich.

LATE SOLUTIONS.

1022, 1024. *Carlton Jencks, Lewis and Clark H. S., Spokane, Wash.*

SOLUTIONS OF PROBLEMS.

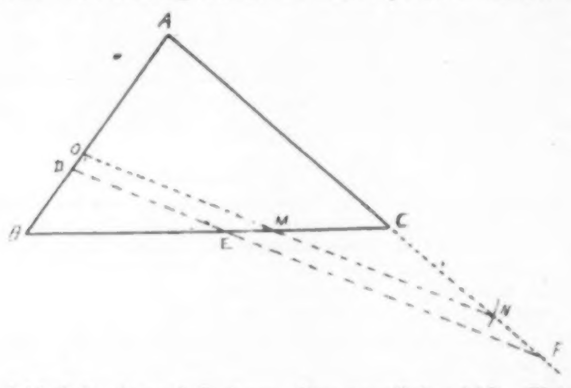
1025. *Proposed by E. de la Garza, Brownsville, Texas.*

Given a triangle ABC, to draw a line, DE, limited by the sides of the angle A, such that DE = DA = EC, D being on AB.

I. *Solved by Bessie Green-Andrews, Wichita, Kansas.*

Editor.—This solution sets up the construction for DE = DA = EC.

On BC mark BM = AB, and with M as center and radius AB cut AC at N. Draw NM cutting AB at O. Find point P on AC such that



AP/CP = BM/BO; through P draw a line parallel to NO. This line cuts BC and AB in the required points E and D.

Proof. By the *theorem of Menelaus,*

$$(AD/DB) \times (BE/EC) \times (CP/AP) = 1.$$

Since $(CP/AP) = (BO/BM) = (BD/BE)$, AD = EC.

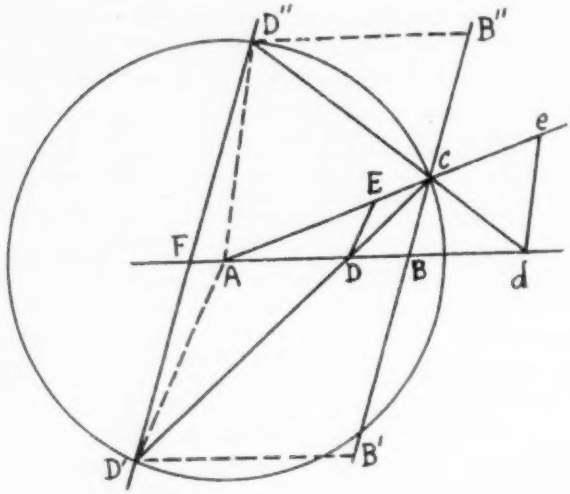
Also by same theorem, using triangle ADP and BC as a transversal,

$$(AD/DB) \times (DE/EP) \times (CP/AC) = 1.$$

$(CP/AC) = BO/(BM - BO) = BD/(BE - BD)$. Since MN = AB, AB/EP = CM/CE. But CM = (BC - AB) which equals (BE - BD), as EC = AD. Therefore CE = DE.

II. *Solved by George Sergent, Tampico, Mexico.*

Analysis. Suppose the problem solved. Draw through A the parallel to ED, intersecting CD produced in D′. Through D′ draw the parallel D′B′ to AB, intersecting CB produced in B′. The quadrilaterals CEDB and CAD′B′ are directly homothetic. The latter can be constructed from the data, for CA = AD′ = D′B′, and D′B′ ∥ AB.



Construction. With A as center and AC as radius draw a circle. On BA lay off BF = CA. Through F draw the parallel to BC. Let D′, within ∠C, and D″, within ∠B, be its intersections with the circle. Draw D′C, which determines D on AB. The parallel from D to D′A determines E on AC. DE is the required line.

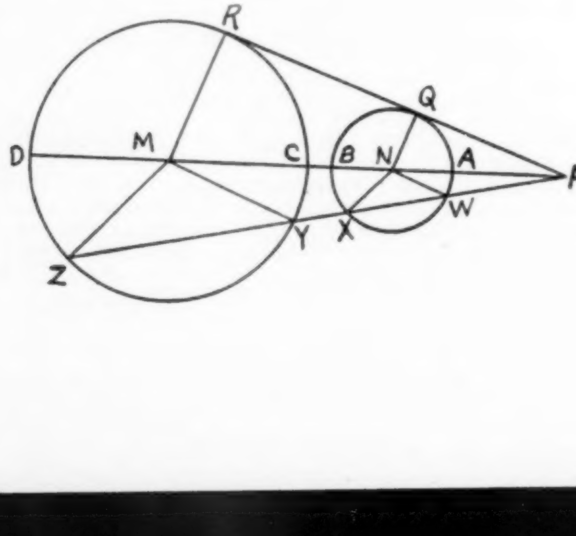
If D″C is drawn, it intersects AB produced in *d*, and the parallel from *d* to AD″ determines *e* on AC produced, *de* = *d*B = *e*C. To prove it, draw between D′D″ and BC the parallel D″B″ to FB. The quadrilaterals CAD″B″ and C*ed*B are inversely homothetic, and since the three sides D″A, D″B and AC of the first are equal, the corresponding sides *de*, *d*B, *e*C, of the second are equal.

1026. *Proposed by Volney Weir, Versailles, Indiana.*

A line through the centers of two given unequal circles intersects the common external tangent at P, and the two circles at A, B, C, and D. If a secant is drawn from P intersecting the circles in W, X, Y, and Z, taking the points in order from right to left, prove that PW × PZ = PX × PY. (Newall and Harper, Plane Geometry.)

Solved by Raphael Robinson, Bakersfield, Calif.

Let PQR be the common tangent to circles M and N. Since the triangles PNQ and PMR are similar, PN/PM = NQ/MR. Since NQ = NW and MR = MY, PN/PM = NW/MY.



Triangles PNW and PMY are similar, since $\angle P = \angle P$ and PN/PM = NW/NY. Therefore

$$PW/PY = PN/PM.$$

Similarly, $PX/PZ = PN/PM.$

Hence, $PW/PY = PX/PZ.$

Therefore $PW \times PZ = PX \times PY.$

Also solved by *George Sergent, Tampico, Mexico; R. T. McGregor, Elk Grove, Calif.; J. K. Ellwood, Federalsburg, Md.;* and *S. M. Turrill, Crane Tech. H. S., Chicago, Ill.*

1027. *Proposed by the Editor.*

Find the integral values for a, b, and c, such that each of the following expressions is the square of an integer:

$$a^2+b^2,\ a^2+c^2,\ b^2+c^2.$$

Solved by F. A. Cadwell, St. Paul, Minn.

While this may not be the kind of solution required, it indicates a method by which values for a, b and c which satisfy the conditions of the problem may be found.

Let p and q be one pair of both even or both odd integers whose product is a^2 and let $p>q$.

Let r and s be another pair of both even or both odd integers whose product is a^2, and let $r>s$. Let

$$b=\frac{p-q}{2} \text{ and } c=\frac{r-s}{2}.$$

From Lemma 3 of solution of problem 948, it can be deduced that: (a^2+b^2) and (a^2+c^2) are squares of integers. Then the problem is to find an integer, a, such that

$$\left(\frac{p-q}{2}\right)^2+\left(\frac{r-s}{2}\right)^2 \text{ or } (b^2+c^2) \text{ is the square of an integer.}$$

By trial of integers consecutively (omitting primes and doubles of primes, whose squares have not two sets of integral factors as required), we come to $a=44$.

$$\begin{aligned}44^2&=968\times 2\\&=484(p)\times 4(q)\\&=242(r)\times 8(s)\\&=88\times 22\end{aligned}$$

$$\frac{484-4}{2}=240 \text{ and } \frac{242-8}{2}=117$$

240^2+117^2 is the square of an integer.

Therefore 44, 117 and 240 is one set of values for a, b, and c such that (a^2+b^2), (a^2+c^2) and (b^2+c^2) are squares of integers. Another set is 85, 132 and 720.

Let n be any integer. Then $44n$, $117n$, $240n$ and $85n$, $132n$, $720n$ are other sets.

Also solved by *Howard Grossman, Brooklyn, N. Y.*

1028. *Proposed by S. M. Turrill, Crane Junior College, Chicago, Ill.*

Upon each side of a scalene triangle construct (outwardly) equilateral triangles. Find the center of gravity of each of these triangles. Prove by methods of Plane Geometry that the center of gravity points determine an equilateral triangle.

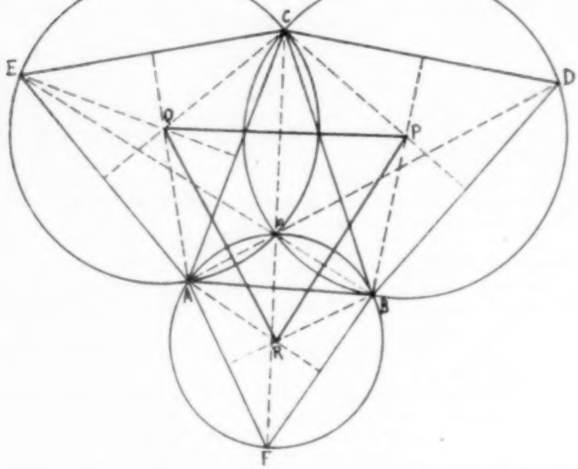
Solved by George Sergent, Tampico, Mexico.

Let ABC be the triangle, BCD, ACE, ABF, the equilateral triangles constructed outwardly on a, b, c, and P, Q, R, their centers of gravity. In each of these equilateral triangles, the center of gravity is at the intersection of the altitudes.

(a) Draw the circumcircles of the $\triangle$'s BCD and ACE, and let O be their intersection. We have

$$\angle BOC = 180° - BDC = 120°$$
$$\angle AOC = 180° - AEC = 120°$$

Hence $\angle AOB = 120°$, and O is on the circumcircle of the equilateral $\triangle ABF$.



(*b*) $\angle DOB = DCB = 60°$. Consequently AOB and DOB are supplementary and AOB is a straight line. Likewise, BOE and COF are straight lines.

(*c*) The $\triangle$'s ABD and FBC are equal for $AB = FB$, $BD = BC$, $\angle ABD = 60° + B = FBC$. Hence $AD = CF$. Likewise, the $\triangle$'s BCE and DCA are equal and $BE = AD$. Therefore $AD = BE = CF$.

(*d*) In the equilateral $\triangle BCD$, CP is two-thirds of the altitude. Therefore

$$CP = \frac{2}{3} \times \frac{a\sqrt{3}}{2} = \frac{a\sqrt{3}}{3} \text{ and } \frac{CP}{CD} = \frac{\sqrt{3}}{3}.$$

$$\text{Similarly, in } \triangle AEC, \frac{CQ}{CA} = \frac{\sqrt{3}}{3}.$$

Hence the $\triangle$'s PCQ and DCA are similar, for $CP : CD = CQ : CA$, and $\angle PCQ = DCA = 60° + C$. Consequently $PQ : AD = \sqrt{3} : 3$. (1). In the same way, by the similar $\triangle$'s PBR and CBF, $PR : CF = \sqrt{3} : 3$. (2), and by the similar $\triangle$'s QAR and EAB, $RQ : BE = \sqrt{3} : 3$. (3). Comparing the last three proportions, we have:

$PQ : AD = PR : CF = RQ : BE$, and since $AD = CF = BE$, we get $PQ = PR = RQ$. Hence the $\triangle PQR$ is equilateral.

Also solved by *E. de la Garza, Brownsville, Texas; F. A. Cadwell, St. Paul, Minn.; H. D. Grossman,* (two solutions), *Brooklyn, N. Y.;* and the *Proposer.*

1029. *Proposed by L. S. Guss, Austin H. S., Austin, Minn.*

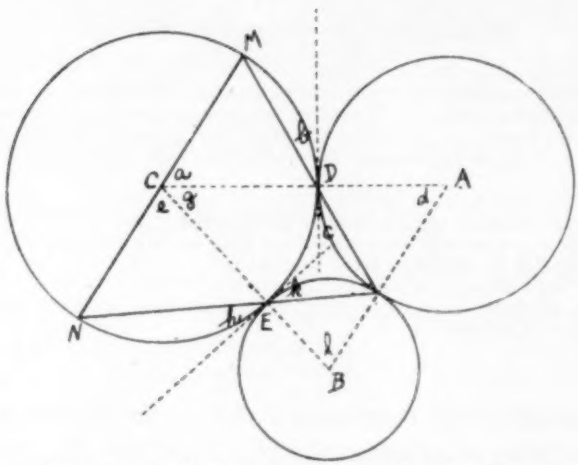
Three circles, A, B, and C are tangent externally. From the point of tangency of A and B, two lines are drawn, one through the point of tangency of B and C, the other through that of A and C. These lines cut the circle C at the points M and N. Prove that MN is the diameter of the circle C.

Solved by Charles E. Burgener, Louisville, Colo.

Draw the common tangents at D and E. Draw MC, NC, BC, and AB.

$$\angle a = 2\angle b \qquad \angle e = 2\angle h$$
$$\angle d = 2\angle c = 2\angle b \qquad \angle l = 2\angle k = 2\angle h$$
$$\angle a = \angle d \qquad \angle e = \angle l$$
$$\angle d + \angle l + \angle g = 180.$$
$$\angle a + \angle e + \angle g = 180.$$

Hence MC and NC form a straight line, and M and N determine a diameter.



Also solved by *Raphael Robinson, Bakersfield, Calif.; Carlton Jencks, Lewis and Clark H. S., Spokane, Wash.; H. G. Ayre, Waukegan, Ill.; George Sergent, Tampico, Mexico; J. K. Ellwood, Federalsburg, Md.;* and *S. M. Turrill, Crane Tech. H. S., Chicago, Ill.*

1030. *Proposed by George Sergent, Tampico, Mexico.*

For any given triangle, ABC, prove that

$$\frac{\sin(A-B)}{\sin(A+B)}=\frac{a^2-b^2}{c^2}.$$

Solved by E. de la Garza, Brownsville, Texas.

$$\frac{\sin(A-B)}{\sin(A+B)}=\frac{\sin(A-B)\sin(A+B)}{\sin^2(A+B)}$$

$$=\frac{\sin^2A\cos^2B-\cos^2A\sin^2B}{\sin^2(A+B)}$$

$$=\frac{\sin^2A-\sin^2B}{\sin^2C}. \qquad (1)$$

But from the Law of Sines,

$$a/\sin A=b/\sin B=c/\sin C=2R,$$

where R is the radius of the circumcircle. Hence $\sin A=a/2R$, $\sin B=b/2R$, and $\sin C=c/2R$. Substituting these values in (1) we get the desired result,

$$\frac{\sin(A-B)}{\sin(A+B)}=\frac{a^2-b^2}{c^2}.$$

Also solved by *Sudler Bamberger, Harrisburg, Pa.; Clyde Bridger, Walla Walla, Wash.; Raymond Huck, Johnson City, Ill.; Justus Siebert, Tilden Tech. H. S., Chicago, Ill.; Harry E. Williams, Ironton, Ohio; Francis Hennessey, Boston, Mass.; F. A. Cadwell, St. Paul, Minn.; Kate Bell, Spokane, Wash.; S. M. Turrill, Crane Tech. H. S., Chicago, Ill.;* and the *Proposer.*

PROBLEMS FOR SOLUTION.

1043. *Proposed by R. T. McGregor, Elk Grove, Calif.*

Without using the Calculus, evaluate the following expression:

$$(\operatorname{cosec}A)^{\tan^2 A} \text{ for } A=90°.$$

1044. *Proposed by Michael Goldberg, Washington, D. C.*

Inscribe one given triangle in another given triangle.

1045. *Proposed by Secran.*

Obtain the real solutions of the following set of equations:

$$X^3+XY^2=Y^3+X^2Y=1.$$

1046. *Proposed by Carlton Jencks, Spokane, Wash.*

Given any triangle: to construct an equilateral triangle so that one of its sides shall be parallel to a side of the given triangle, the extremities of this side are to lie in two sides of the given triangle and the vertex opposite this side is to lie in the remaining side (or the side extended) of the given triangle.

1047. *Proposed by J. F. Howard, San Antonio, Texas.*

Given O—ABC a tetrahedron with tri-rectangular trihedral angle at O. Prove that the square of the area of face ABC equals the sum of the squares of the areas of faces AOB, BOC and AOC.

1048. *Proposed by S. W. Hockett, Oskaloosa, Iowa.*

Give a solution of the following set of equations which is suitable for High School students:

$$X^2+Y^2=13$$
$$X^3+Y^3=35.$$

AMERICANS FURNISHED FUEL FOR ZEPPELIN.

Three thousand cylinders of special gas fuel for the German dirigible Graf Zeppelin were provided at Lakehurst, N. J., to fuel the ship for its return voyage across the Atlantic.

Unlike the Blau gas fuel that the airship used on its voyage to America, the million cubic feet of American product is made from fractionated natural gas and is a synthetic mixture of ethane, about the density of air, methane, lighter than air, propane and butane, both heavier than air. These gases are carefully proportioned until the resulting mixture has a density of 1.05, only slightly heavier than air. Arrangements for the supply of this gas by a Louisville, Ky., concern were made by the U. S. Navy as an act of courtesy to the German ship which is the guest of its sister, the dirigible Los Angeles, in its large two-berth hangar at Lakehurst.

Both the German Blau gas, so-called because it was first made by a German by that name, and the American substitute, allow the dirigible to carry fuel which adds practically no load and does not make the ship lighter when it is burned, since it is nearly the weight of air. The fuel gas is carried in extra ballonets at the bottom of the giant envelope.

Blau gas is made by the distillation or cracking of gas oil, one of the heavier constituents of the refining of petroleum. In Germany it is obtainable commercially for heating and illuminating purposes and a plant is located at Friedrichshafen, the home port and place of manufacture of the Graf Zeppelin.

The use of air-weight gas fuel eliminates the necessity of a water-recovery apparatus such as devised by American government engineers for the conservation of weight on the dirigible Los Angeles. Any fuel when burned produces water by the union of the hydrogen of the fuel and the oxygen of the air and as this water is about equal in weight to the fuel consumed, it will maintain equilibrium of the ship if it is condensed from the exhaust gases and conserved. Such water recovery has worked successfully on the dirigible Los Angeles and it will be a question for future experience to determine which system will be used on the dirigibles of the future. Not all the fuel of a trip can be carried in the form of fuel gas, however, and Graf Zeppelin relies largely on gasoline as the hundred or so Zeppelins did before her.—*Science News-Letter.*

CHEMISTRY OF NITROGLYCERINE.

By Dr. R. E. Rose,
Wilmington, Del.

A microbe is a lowly thing, God wot, too small to see, a mere speck but multiplying rapidly to hordes that feast upon us and instead of giving thanks for charity received plague us with colds, measles, grippe and even pneumonia, t. b. and those other invasions that often put a period to our lives.

But I wish to laud the microbe, not to curse him. I am prepared to show that it was he who built the Panama canal. Dynamite, the engineer will tell you, was absolutely essential to the making of that world wonder joining Atlantic and Pacific. The real marvel is then the dynamite, but dynamite is a mixture of nitroglycerine and ammonium nitrate with more or less ground wood.

Nitroglycerine is a thick oily material made from nitric acid and glycerine; ammonium nitrate is a crystalline solid made from nitric acid and ammonia; nitric acid is made, or at least was made at the time of the excavating of the canal, from sodium nitrate or Chile salt-peter. Chile salt-peter is made in nature by the oxidation of animal matter by the action of microbes; the animals get their nitrogen from other animals or plants, and plants get theirs from bacteria or from dead plants or animals. Finally at the end of the trail we come to the little nodules on the roots of a clover plant (pull one up and you'll find them).

In those tiny factories microbes burn up sugar and bind the nitrogen of the air into protein. Protein contains a great deal more energy than the nitrogen, water and carbon dioxide out of which it is made. In the dark these microbes worked the miracle of building molecules and putting energy into them. The energy stayed in the protein, stayed in the Chile salt-peter and burst out when the nitroglycerine and ammonium nitrate of the dynamite exploded.

Who dug the Panama canal? Azo bacter, the little microbe who put the energy into the dynamite. Where did he get it? From the sun,—but how could he, he worked in the dark. We have struck another mystery.

But before turning to that, let us give thanks to


CHRISTMAS GREETINGS
1928

Chevrene, to Sobrero, Von Armstrong and to Nobel, chemists who taught us how to pack the energy of the microbe's work into nitroglycerine and to the manufacturers of dynamite who have made of it a cheap commodity available to farmer, engineer, quarryer and ditch-digger.

JOSEPH LISTER (1827-1912).

On December 12, sixty-one years ago, the celebrated British Surgeon, Joseph Lister, initiated a rather simple experiment that went far toward establishing the principle of "antisepsis" which in turn made possible the marvels of modern surgery. Lister had observed that a bit of metal or glass might be included within the body for an indefinite length of time without causing trouble whereas silk or linen thread used for stitching wounds almost always led to inflammation or festering, and interfered with healing. Suspecting that this was due to the presence of germs in the pores of the thread, he decided to make sure by experimental means. Accordingly on December 12, 1867, he sewed together the cut end of the great blood-vessel in the neck of a horse with silk that had been soaked for some time in solutions of carbolic acid. The wound was closed at once, and healed promptly, without producing inflammation or pus, without fever, without complications. A few weeks later, he carefully examined the artery to make sure that all conditions were favorable to the welfare of the animal. Encouraged by the complete success of the experiment, he said: "I feel justified in carrying a similar practice into human surgery." As a result of further experimentation on animals, Lister was led to substitute "catgut" for silk; and this has been used ever since in practically the same way as originally worked out.

It was also in 1867 that Lister published his first paper on "Antiseptic Surgery" following his success in the use of sterilized sponges and instruments, and in applying dressings saturated in carbolic acid to the wound or cut. The prevailing opinion before Lister made his experiments looked upon suppuration or festering as a necessary part of natural healing, which should not be interfered with. This opinion was opposed by the central idea of Lister's system—the destruction of the invisible organism which he correctly suspected of causing suppuration. In the face of constant criticism he worked to improve his system and lived to see the antiseptic principle accepted by surgeons the world over. "Listerism," it has been said, "saved more lives by the end of the 19th century than all the losses of life through war in the 18th century."

Today we casually apply iodine or some other antiseptic to a scratch or a larger wound, and thus prevent infection by pus-forming organisms and even more serious infections. Few of us who apply this simple measure of "first aid," which has become standard practice, appreciate either how much harm is thereby prevented or how much thinking and experimenting were required to establish the principle.

SCIENCE QUESTIONS.

CONDUCTED BY FRANKLIN T. JONES.

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

QUESTIONS AND PROBLEMS.

527. *Proposed by Prof. Douglas I. Bates, College of Engineering, Oregon Institute of Technology, Portland, Oregon.*

When the air about an organ pipe changes temperature, which changes, the frequency or the wave length of the sound, if we neglect any expansion or contraction of the organ itself?

WANTED.

Some problems and questions that will make the readers of this Department sit up. Send your examination questions. Send some of the answers in your "tests." *"If things interest you, they will interest us."*

EXAMINATION PAPER.

CHEMISTRY

JUNE, 1928, COLLEGE ENTRANCE EXAMINATION BOARD

Answer eight questions as indicated below.

Number and letter your answers to correspond to the questions selected.

Note: No credit will be given for problems on this paper unless the methods of calculation are clearly indicated. The units in which the final numerical answers are expressed must be given, but need not be carried beyond one place of decimals.

PART I.

(Answer all questions in Part I.)

1. Describe briefly but clearly what you would observe if you carried out each of the following experiments, and write balanced equations for the principal reactions:
   a) Dilute potassium chloride solution is added to dilute silver sulphate solution;
   b) Dilute hydrochloric acid is poured over some iron filings;
   c) Dilute nitric acid is poured over some pieces of copper;
   d) A mixture of zinc dust and powdered sulphur is cautiously heated.
2. Carbon monoxide is a reducing agent, nitric acid is an oxidizing agent. Give an example, with an equation, to illustrate each action.
3. To prepare hydrogen chloride, 58.5 grams of sodium chloride are treated with sulphuric acid—

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl.$$

   a) What is the minimum weight of pure sulphuric acid that will suffice? What is the maximum weight of hydrogen chloride that can be produced?
   b) If this amount of hydrogen chloride is entirely dissolved in water, what weight of calcium carbonate would the solution dissolve?

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2.$$

   c) What volume of carbon dioxide would be evolved in the last reaction? (Atomic weights: Na = 23, H = 1, S = 32, O = 16, Ca = 40, C = 12, Cl = 35.5. Weight of 1 liter of CO_2 = 1.97 grams. Gram-molecular volume = 22.4 liters.)

   See note at beginning of question paper.
4. Describe *two* of the following processes briefly but clearly, mentioning any special conditions necessary (temperature, pressure, or catalytic agent):

a) Preparation of oxygen from liquid air;
b) Preparation of nitric acid from the nitrogen of the air;
c) Preparation of sulphuric acid from sulphur;
d) Laboratory method for the preparation of chlorine.

5. Explain in terms of the ionic theory the following: (a) the electrolysis of hydrochloric acid; (b) neutralization; (c) what occurs when barium chloride solution is mixed with sulphuric acid; (d) why a water solution of sodium carbonate is alkaline to litmus, while a solution of sodium chloride is neutral.

PART II.

(*Answer only three questions in Part II. Answers to extra questions will receive no credit.*)

6. Explain the action that goes on in each of the following:
 a) Cotton cloth is bleached by chlorine.
 b) Certain materials are bleached by sulphur dioxide.
 c) Concentrated sulphuric acid is a dehydrating agent.
 d) Nitric oxide turns brown on exposure to air.

7 Give a chemical test (or tests), including equations, by which you could completely identify *four* of the following: (a) hydrogen sulphide; (b) ammonium chloride; (c) ferric nitrate; (d) carbonic acid; (e) sodium sulphate. State the essential observations for each test, and write equations, if any.

8. How many liters of oxygen are required for the *complete* combustion of one liter of each of the following gases, assuming that the volumes of all the gases are measured at 100°C. and that the pressure is standard throughout: (a) hydrogen; (b) methane (CH_4); (c) acetylene (C_2H_2); (d) hydrogen sulphide? Write the equations and represent the volumes of the various gases (including the combustion products) by means of squares.

9. How do you explain the facts that a solution of copper sulphate (a) has a blue color, (b) conducts the electric current, and (c) will coat an iron nail with copper?

10. a) When carbon dioxide is passed into limewater, a precipitate forms which disappears when an excess of carbon dioxide has been added, and reappears when the solution is boiled. Explain, writing equations.
 b) Write an equation to show what change occurs when a permanently hard water is softened.

11. Are the following statements true or false? Give a reason for or an illustration of your answer in each case. (Make a vertical list in correct order, labeling "true" or "false" as the case may be.)
 a) Carbon is an excellent reducing agent.
 b) Carbon reacts with water to form carbonic acid.
 c) Carbon forms stable compounds with oxygen, as well as many organic compounds with hydrogen, and with hydrogen and oxygen.
 d) Carbon in the form of charcoal is a good absorbent.
 e) A metallic element like carbon displaces the hydrogen in acids.
 f) Some form of carbon is used extensively in metallurgy.

SOLUTIONS AND ANSWERS.

526-*Proposed by John C. Packard, Brookline, Mass.*

Hanging over a pulley there is a rope with a weight at one end; at the other end hangs a monkey of equal weight. The rope weighs 4 oz. per foot. The combined ages of the monkey and its mother are 4 years and the weight of the monkey is as many pounds as its mother is years old. The mother is twice as old as the monkey was when the mother was half as old as the monkey will be when the monkey is 3 times as old as its mother was when she was 3 times as old as the monkey was. The weight of the rope and weight is half as much again as the difference between

Patterns 2 and 11

Pattern No. 2

Jewell Pattern Nos. 2 and 11 D. C. and A. C. portable instruments are always a desirable addition to the school laboratory equipment where ruggedness as well as accuracy is desired.

The movements used are the results of years of instrument development and have many desirable features, which, we believe, are not duplicated in other instruments of comparable design.

Scales of these instruments are long (6¾ inches), clean cut and easy to read. They are hand drawn on white bristol board and backed by a mirror to prevent parallax errors. The knife edge pointers enable readings to a guaranteed accuracy of ¼ of 1% full scale value.

The enclosing case is natural finish lock joint walnut, 8¾x7⅛x4¼ inches, and is equipped with snap hinges and a leather carrying handle.

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—JEWELL—

the weight of the weight and the weight of the weight plus the weight of the monkey. What is the length of the rope?

[*Two* checked up and their answers are given below. If I were Will Rogers, I'd say the rest of you didn't dare send in your solutions.—*Ed.*]

From John J. Kinsella, Piedmont, New York.

Let x = age of mother in years now
$(4-x)$ = age of monkey in years now
z = no. yrs. ago mother was 3 times as old as monkey
$x-(4-x)=(2x-4)$ = no. yrs. older mother is than monkey
$(x-z)$ = her age z yrs. ago
$(4-x-z)$ = his age z yrs. ago
(1) $(x-z)=3(4-x-z)$ [Last clause in sentence 4 of problem]
(2) $3(x-z)=9(4-x-z)$ = how old he will be when 3 times as old as she was when she was 3 times as he was

(3) $\frac{3}{2}(x-z)=\frac{9}{2}(4-x-z)$ = how old she was when one-half as old as he will be when, etc.

(4) $\frac{3}{2}(x-z)-(2x-4)=\frac{9}{2}(4-x-z)-(2x-4)$ = how old he was when she was etc.

$$\therefore (5) \quad x=2\left[\frac{3}{2}(x-z)-(2x-4)\right]$$

$$(6) \quad x=2\left[\frac{9}{2}(4-x-z)-(2x-4)\right]$$

Simplifying (5) and (6)

$$\begin{aligned}(5)\quad 2x+3z&=8\\(6)\quad 14x+9z&=44\end{aligned}\quad\left.\right\}\quad\begin{aligned}6x+9z&=24\\14x+9z&=44\\\hline -8x&=-20\\x&=2.5\end{aligned}$$

Age of mother = weight of monkey (numerically in lbs.) = 2.5
Let y = length of rope in feet.
$4y$ = no. oz. in wt. rope
(2.5) (16) = 40 = no. oz. in wt. of monkey and wt. of rope

$$\therefore 4y+40=\frac{3}{2}(40+40-40)=\frac{3}{2}(40)=60$$
$$4y=20$$
$$y=5 \quad \therefore \text{Length of rope is 5 feet.}$$

Answer to 526 from Miss Marguerite Schneider, Pima, Arizona.

Dear Sir:

I am sending my solution to problem 526, in the November issue of SCHOOL SCIENCE AND MATHEMATICS."

Let w = wt. of weight in pounds
M = wt. of monkey in pounds
R = wt. of rope in pounds
4R = length of rope in feet = L
A = monkey's age at present
B = mothers age at present

$$R+W=\frac{3}{2}(W+M-W)=\frac{3}{2}M$$

But W = M

$$R+W=\frac{3}{2}M$$

THE TWELVE LONGEST RIVERS.

Of the world's dozen longest rivers, six are in Asia and three in Africa. The New World is represented only by the Amazon in South America and the Mississippi and the Mackenzie in North America, though if the Missouri be considered apart from the Mississippi it would take rank in its own right.

The longest single river is the Nile, measuring some 4,000 miles from head to mouth. The Nile is further distinguished in that it has no tributaries for the last 1,500 miles of its course to the sea. During this stretch its waters are considerably reduced in volume by evaporation and irrigation, so that it grows smaller instead of larger toward its mouth.

Other African rivers among the length-scoring twelve are the Niger and the Congo, both fed by the tropical rains of hot regions near the Equator. In a general way they more nearly resemble South America's representative, the Amazon, than the great streams of the colder northern continents.

Of Asia's six longest rivers, four are in Siberia, the Ob, Yenisei, and Lena flowing north into the Arctic Ocean and the Amur emptying into an arm of the Pacific. The other two are the Yangtze and Hwang, or Yellow River of China.

These twelve river basins represent the greatest variety of climate and civilization. The Amazon and the Congo flow through lush equatorial jungles inhabited by birds of brilliant plumage, wild animals and savage tribes, while the mouths of the Yenisei and the Lena are above the northern timber line and their valleys support the sparsest population. The Mississippi and the Yangtze flow through established, if divergent, civilizations, with rich cities along their banks like jewels on a string. The Nile is one of the cradles of world history; the Mackenzie is still a frontier stream.—*Geographic News Bulletin.*

$$\text{But } R = \frac{M}{2}$$
$$\text{While } M = B$$
$$R = \frac{B}{2}$$
$$L = 4R = 4\left(\frac{B}{2}\right)$$
$$L = 2B$$

So the solution depends on finding the present age of the mother and multiplying it by two.

d = difference in monkeys' ages
O = Age monkey once was
B = 2O
x = Age mother once was
y = Youngest given age of monkey
z = Corresponding age of mother
H = Age monkey "will be"

I solved by using two equations in which only B and d were used.

Equation I.

$$A + B = 4$$
$$-A + B = d$$
$$\text{(I)} \quad B = \frac{4+d}{2}$$
$$\text{(II)} \quad B = \frac{5}{2}d$$
$$H = 3z$$
$$\text{(1)} \quad z = 3y$$
$$\text{(2)} \quad H = 3(3y) = 9y$$
$$z - y = d$$
$$\text{(1)} \quad z = 3y$$
$$3y - y = d$$
$$2y = d$$
$$\text{(3)} \quad y = \frac{d}{2}$$
$$x = \frac{H}{2}$$
$$\text{(2)} \quad H = 9y$$
$$x = \frac{9y}{2}$$
$$x - O = d$$
$$\frac{9y}{2} - O = d$$
$$\text{But } B = 2O$$
$$\frac{9y}{2} - \frac{B}{2} = d$$
$$9y - B = 2d$$
$$B = 9y - 2d$$
$$\text{(3)} \quad y = \frac{d}{2}$$

$$B = 9\left(\frac{d}{2}\right) - 2d$$

$$\text{(II.)} \quad B = \frac{5}{2}d$$

$$\frac{5d}{2} = \frac{4+d}{2}$$

$$5d = 4 + d$$

$$4d = 4$$

$$\text{(4)} \quad d = 1$$

$$\text{I.} \quad B = \frac{4+d}{2}$$

$$B = \frac{4+1}{2} = \frac{5}{2}$$

$$\text{So desired length} = 2\left(\frac{5}{2}\right)$$

$$= 5 \text{ feet.}$$

[Come again, Packard. We like your stuff.—*Jones.*]

UNDERSEA CAMERA GETS TIDE DATA.

A unique motion-picture camera, recording automatically the velocity and direction of currents beneath the surface of the water, was used to advantage this past summer by the U. S. Coast and Geodetic Survey during what is stated to be the most comprehensive survey of tide and current conditions in Chesapeake Bay ever attempted.

While the device is so new that it has not yet been perfected fully, it has shown results that indicate it will be used as a regular part of standard current testing equipment. The camera is designed to take the place of a complete human observing unit composed of one boat, one officer and six men. It contains within it a compass and revolution dial of which pictures are made each half hour, and works continuously without attention for an entire week.

The purpose of the Survey's work this summer was to bring aids to navigation, such as mariner's charts and current tables, absolutely up to date. From the data gathered this year and last, current tables will be published from which at any future time the direction and velocity of currents at any place in the Bay may be ascertained. The information likewise will be valuable in enabling engineers of surrounding cities to make proper disposal of their sewage. They must know at precisely what point the ebb of the tide will be able to convey the sewage farther out to sea than the flood current is able to bring it back.

Fishing interests will be aided by the data since certain fish are known to bite better at certain tidal stages than at others.

Headed by Lieut. George L. Anderson, the Survey engineers, four all told, conducted their investigations from four 65-foot launches. A unique feature was that 24 college boys, selected from leading universities in the East and Mid-West, acted as special observers, their purpose being to gain technical experience to add to their engineering knowledge.—*Science News-Letter.*

BOOKS RECEIVED.

The Health of Youth by Florence L. Meredith, Professor of Hygiene, Tufts College, Medford, Mass., and Lecturer in Hygiene, Simmons College, Boston, Mass. Cloth. Pages xxviii+535. 13x19.5 cm. 1928. P. Blakiston's Son & Company, 1012 Walnut St., Philadelphia.

Plane and Spherical Trigonometry with Applications by J. Shibli, The Pennsylvania State College. Cloth. Pages xii+217+94. 13x21 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $1.96.

Mineralogy an Introduction to the Study of Minerals and Crystals by Edward Henry Kraus, Professor of Crystallography and Mineralogy and Director of the Mineralogical Laboratory, University of Michigan and Walter Fred Hunt, Professor of Petrology, University of Michigan. Second Edition. Cloth. Pages ix+604. 14x23 cm. 1928. McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York. Price $5.00.

Objective Tests by Jacob S. Orleans Formerly of the Educational Measurements Bureau, New York State Department of Education and Glenn A. Sealy, District Superintendent of Schools, Lewis County, New York State. Cloth. Pages x+373. 12x19.5 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price $2.00.

Experimental Physics, A Laboratory Manual by Albert Edward Caswell, Professor of Physics, University of Oregon. Cloth. Pages ix+181. 14x21.5 cm. 1928. The Macmillan Company, New York.

A Laboratory Manual of General Botany by Emma L. Fisk and Ruth M. Addoms, Department of Botany, University of Wisconsin. Cloth. Pages ix+103. 13.5x21.5 cm. 1928. The Macmillan Company, New York.

Orleans Algebra Prognosis Test by Joseph B. Orleans, Chairman of the Mathematics Department, George Washington High School, New York City and Jacob S. Orleans, Formerly of the Educational Measurements Bureau, New York State Department of Education. Price package of 25 with Manual, Key, and Class Record $1.40 net.

BOOK REVIEWS.

Plane Geometry, by Joseph P. McCormack, Head of the Department of Mathematics in the Theodore Roosevelt High School, New York City. Pages xii+371. 14x19.5 cm. D. Appleton and Company, 35 West 32nd St., New York City. Price $1.40.

This book shows evidence of careful thought in its planning and an immense amount of work in collecting and arranging the material. We note the following features.

1. All propositions of the fundamental list of the National Committee and the required list of the College Entrance Board are marked, the former by bold faced type and the latter by stars. All others are printed in italics.

2. The course is flexible. There is material to satisfy the needs of students of all shades of ability. The exercises, of which there is an abundance, are divided into two groups.
   (1) Class exercises to be assigned to all the members of a class.
   (2) Optional exercises for classes in average ability.
   (3) Honor work for pupils of upper rank.
   (4) Applied problems from various fields.

3. Complete proofs are given for all important propositions.
4. Reasons are required for all constructions.
5. More than usual attention is given to numerical trigonometry.
6. Investigation problems precede the important propositions.
7. Self measuring tests and new type tests. The latter are contributed by Prof. Raleigh Schorling of the University of Michigan.

J. M. Kinney.

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New Analytic Geometry, by Percy F. Smith, Sheffield Scientific School of Yale University, Arthur Sullivan Gale, University of Rochester, and John Have Neelley, Carnegie Institute of Technology. Pages x+326. 14x19.5. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $2.00.

In this revision the authors have retained the first edition which seemed to be popular. The difference between this edition and the old one arises from the arrangement of material, addition of new material, and a thorough revision of the problems. Provision has been made for students of superior ability by adding groups of difficult problems.

J. M. Kinney.

Mathematics in Liberal Education, by Florian Cajori, Professor of the History of Mathematics in the University of California. Pages 169. 14x20.5 cm. Christopher Publishing House, Boston. Price $1.50.

After having reviewed the contributions made by the psychologists on the problem of determining the educational value of mathematics, Professor Cajori came to the conclusion that little had been accomplished by them. He then proposed a new approach to a solution of the problem. It occurred to him that we are not so superior to the thinkers of former ages that their observations are worthless as compared with our own.

Accordingly, he set himself the task of collecting the opinions of the leaders of the past and present of the value of mathematics in a liberal education, both favorable and adverse. Of the 731 opinions canvassed he found that 603 favored and 128 opposed the high value of mathematics in liberal education. Quotations of these opinions are found in this book.

J. M. Kinney.

Elements of Machine design, by James D. Hoffman, M. E., Head of the Department of Practical Mechanics and Director of the Practical Mechanics Laboratories, Purdue University, Lafayette, Indiana and Lynn A Scipio, M.E., Dean of Robert College School of Engineering and Professor of Mechanical Engineering, Robert College, Constantinople, Turkey. Cloth. Pages vii+327. 14.5x23 cm. 1928 Ginn and Company, Chicago, Ill. Price $3.80.

In preparing this book the authors have attempted to present the subject in such a manner that the student will be able to acquire a great amount of information in a short time. Students are taught to apply formulas rather than to develop them. This plan of attack starts the student out on the practical applications of the subject thus securing his interest from the beginning and developing his ability to study for himself.

In the first part of the book the fundamental principles of machine design are presented. This division consists of eleven short chapters each of which develops the basic theory of a topic and gives a number of illustrative problems with their solutions. Diagrams are found on nearly every page and each chapter is followed by a list of references and a list of problems for solution. The second division consists mainly of five illustrative designs. Here the student is taught to apply the principles developed in the first section of the book and learns to visualize the various parts of each machine in relation to the machine as a whole. The procedure of the authors in first introducing the students to problems in statics and then proceeding to the more difficult phases involved in kinetics is pedagogically sound. The book has been carefully edited and is a very creditable addition to the splendid list of scientific and technical books put out by the publishers.

G. W. W.

The Early Mathematical Sciences in North and South America, by Florian Cajori, Ph.D., Professor of the History of Mathematics, University of California. Illustrated. Cloth. 156 pages. 13x20 cm. 1928. Richard G. Badger, Publisher. The Gorham Press, Boston.

This book is a very interesting account of the scientific achievements of the Americans during the periods of discovery and colonization, and the early national period. In it the author tells of the mathematical and scientific knowledge of the Mayas, the number system of the Peruvians, the calculations of Columbus, the instruments used by Champlain, the obstacles encountered by Mason and Dixon and a thousand other interesting items telling the difficulties of the early explorers and surveyors due to inaccurate instruments and insufficient knowledge of details. The activities of many of the early American students of science centered about astronomical observations because of the importance of such knowledge in surveying, map drawing and navigation. In this they were aided by English scientists who sent them instruments, books and even observers, but this friendly cooperation was interrupted by the Revolution and was not restored until many years later. Many such sidelights on the progress of science in the New World are told in an interesting manner. The book is a valuable addition to the history of science book-shelf but unfortunately it is so poorly bound that it will not stand long usage in any public or school library.

G. W. W.

Old Mother Earth, by Kirtley F. Mather. Pages xiv+177. 61 illustrations, 20x13 cm. 1928. Price $2.50. Harvard University Press, Cambridge, Mass.

This little book by Professor Mather who is Professor of Geology at Harvard University is the result of a series of radio talks over station WEEI during the winter of 1927-28. There are 15 chapters, each complete in itself including such subject as "How The Earth Was Made," "Origin Of Life," "Earthquakes," "Evolution Of Mankind," "Geology And Genesis." Each chapter has been revised, expanded, and profusely illustrated with maps and photographs. The book is written in a very pleasing and attractive style. Placed in a high school library it will be read with avidity and will be a great stimulus to further science reading and study. For this purpose it is the best written book the reviewer has read in many years. Every science library should possess a copy.

C. M. T.

First Course in Botany, by Raymond J. Pool, Ph.D., University of Nebraska, and Arthur T. Evans, Ph.D., South Dakota State College of Agriculture and Mechanic Arts, with the Editorial Co-operation of Otis W. Caldwell, Ph.D., Director of the Lincoln Institute, Columbia University. Cloth. 13x19 cm. ix+414 pp., with 219 figures in the text. Published by Ginn & Company, 1928. Price, $1.64.

It seems strange that prospective authors of text books for secondary schools should think that knowledge of the subject is all that is needed in the way of equipment for the task. This is especially true of university men. It apparently does not occur to them that some familiarity with practices in vogue in the best high schools might be wise, nor that teacher organizations may have been at work on the best methods of presentation of subjects in the curricula.

In the present book there is no indication that the work of such organizations has been studied or even known. Committees of the North Central Association and of the National Education Association have been at work on the biological courses for some time and have issued reports looking to the reorganization of these courses in the curriculum. If new textbooks were written with the work and recommendations of these committees in mind, teachers of these subjects would find it much easier to profit by these recommendations.

The authors of the first course in Botany lay considerable stress upon the logical order of presenting the topics. But of what use is the logical order of presentation, if it does not fit the conditions under which the subject must be presented? Botany is a seasonal subject. Beginning students should have an abundance of fresh material to work with. Few secondary schools have access to greenhouses or have large stores of preserved materials as is the case in the college. A textbook could be arranged to fit these conditions so that the teacher might make the utmost use of fresh growing material, but the authors have chosen an order most convenient to them—the usual method of presenting the subject in college.

However the book is well written, the presentation of the facts good and the language and style simple enough for second year high school pupils to read and understand. The illustrations are well chosen and, in fact, the entire book shows much careful effort to present the topics in the best manner. We think the authors could have made a book much better suited to high school condition, but in spite of this, it will prove a boon to teachers of botany who can take advantage of it. W. W.

A Laboratory Manual for First Course in Botany, by Arthur T. Evans, Ph.D., Professor of Botany in the South Dakota State College, with Editorial Co-operation of Otis W. Caldwell, Ph.D., Director of Lincoln Institute. Cloth. 13x19 cm. pp. 155, illustrated with 49 cuts. Published by Ginn and Company. 1928. Price, 72c.

This manual is designed to accompany First Course in Botany but can, of course, be used with any text. Many teachers in small schools are overloaded with work and greatly need the help of a manual. It may contain suggestions for others who are not so hard pressed with teaching several subjects. The lessons are carefully worked out and best of all, contains explanatory statements where the students need help to understand new material, or new principles which arise in the course of the study. We can recommend this book for those who need such help. W. W.

Principles of Plant Physiology, by Oran Raber. Cloth. Size 13x20 cm. pp. xiii+378, illustrated with plates and figures. Published by The Macmillan Company, 1928.

This book was written for the student rather than for the teacher, and is therefore not intended for an exhaustive treatise of the subject. It seems to be a very complete exposition of the subject from this standpoint, and will be very valuable to elementary students in college and for biology teachers in secondary schools who wish a readable, up-to-date book on the subject of plant physiology.

A very excellent and interesting portion of the book gives the portraits of eminent living physiologists with a statement of the specialty of each. As the author says the student often gains the impression he is studying a dead science rather than one that is being developed by workers now living and constantly increasing our knowledge of the subject. W. W.

A Textbook of General Botany, by Gilbert M. Smith, Stanford University and James B. Overton, Edward M. Gilbert, Rollin H. Denniston, George S. Bryan and Charles E. Allen, University of Wisconsin. Revised edition. Cloth. Size 13x20 cm. x+539 pp., and illustrated with numerous plates and 416 figures. Published by The Macmillan Company, 1928.

This edition has been extensively revised by the authors and considerable new material added. The book is profusely illustrated and there are a considerable number of plates of botanists distinguished in the development of botany during the early stages of the science. It was written for the use of elementary students but is quite comprehensive in the development of the topics. It is a good book worthy of consideration by those teaching elementary college classes and well worthwhile for the library of the secondary school botany teacher. W. W.

Algebra for Secondary Schools, by Stephen Emery and Eva E. Jeffs, Erasmus Hall High School, Brooklyn, New York. Pages x+626. 14.5x20.5 cm. 1928. D. Van Nostrand Company, Inc., 8 Warren St., New York. Price $1.85.

The arrangement of material in this book is unusual. The first 208 pages are filled with a list of 3019 verbal problems. This list is divided into groups A to G. These groups are further divided. Thus Group D is divided into the subgroups, Number and Value; Work; Metric System; Specific Gravity; Mixtures; Motion; Fractions; Similar Triangles and Rectangles; Circle and Sphere; and Clocks.

These problems are to be assigned after the completion of corresponding topics in the text which begins on page 209. The formal material, of which there is a vast amount, is embodied in the text.

The authors do not expect the student to learn all parts of the book with equal completeness. In fact it is not intended that any one group of students shall necessarily cover the entire text.

J. M. Kinney.

Educational Biology, by William H. Atwood, Milwaukee State Teachers' College and Elwood D. Heiss, Milwaukee State Teachers College. xi+469 pp., 259 illustrations. $2.75. P. Blakiston's Son & Co. 1928.

This book was written for use with first year classes in normal schools and teachers' colleges. It presents a background course using plants and animals to illustrate the fundamental principles of elementary biology. The aims which have guided the authors in writing the text are stated as follows: To give a general outline of the scope of biology and its relation to the other sciences and to education. To develop scientific attitudes which may aid the teacher in evaluating educational theories and problems. To provide a biological basis for a better appreciation and understanding of other teacher-training subjects; such as hygiene, physical education, psychology, history and sociology. To give the student a rational basis for interpreting the important biological problems which are pertinent to the needs of the community, and to furnish a background which shall aid in molding a public sentiment that will respect the findings of the science of biology. To give an understanding of the general principles and theories of the science which are of importance in liberal education.

The authors have held to these aims in selection and treatment of subject matter. Teacher helps and student helps are provided in the form of questions for review, references as guides to extended study, suggestions for laboratory study and a glossary. The book is well illustrated and the printing and binding are excellent. For those desiring a treatment of biological materials more extensive than that of the high school texts for reference, general reading, or for class use, this book should prove valuable.

Jerome Isenbarger.

RUBBERIZED VIOLINS.

Modern violins may be made to rival the product of the old masters by impregnating the wood with rubber latex before varnishing, according to the claim of a German investigator named Ditmar-Graz, writing in the scientific magazine *Natur und Kultur*. He states that this treatment causes the wood to remain permanently elastic.—*Science News-Letter*.

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